Vision for Participatory Systems Design

Frances Brazier/TU Delft

Delft University of Technology
Systems engineering group
Faculty Technology, Policy and Management
Delft, The Netherlands
F.M.Brazier@tudelft.nl

Caroline Nevejan/TU Delft

Delft University of Technology
Systems engineering group
Faculty Technology, Policy and Management
Delft, The Netherlands
C.I.M.Nevejan@tudelft.nl

Abstract—**In today's world large distributed ICT is affecting many processes of individual and societal developments. Driven by new technology new types of systems are emerging - participatory systems - systems that have acquired power and agency. At first such systems most often initiate within communities of practice. Some succeed, some don't (the leading principle seems to be based on trial and error).**

Defining 'participatory systems' as (large scale) ICT enabled social-technological-ecological systems in today's networked society, designed with a mission, to provide a technological, social and ecological infrastructure to support participation provides the grounds for a framework. This framework provides a methodology for value-based design (including analysis) of the structure, networks and governance within a networked system, including accepted design principles and constructs for the design of function, structure, behavior which is extended with human experience (artistic research). Key attributes of participatory system include: autonomy, engagement, merging realities, emergence, self-organization, trust, empowerment, ability to act, ability to take responsibility.

Keywords— *participation, systems design, trust, engagement, empowerment, self organization, emergence*

Introduction

In today's networked world a variety of 'participatory systems' has become of vital importance to individuals and societies at large. New systems designs for a variety of economic markets (food, flowers, finance, electricity) and new systems design for a variety of social networks (communities, healthcare, safety and security, crisis management), are not only based on principles of mandating and delegating, but are primarily grounded in the principle of participation [1]. As result participants in the system acquire both perception and agency as was not possible before. All participants contribute to the shared domain and participants benefit from this sharing.

Distributed ICT makes it possible to participate, to share and benefit because it is capable of facilitating process of co-creation, negotiation and adaptation in real time and at grand scale. Participatory systems are large distributed complex systems and have distinct dynamics of adaptation, emergence and self-organization, which demands specific methodologies for design.

Participation is defined as to be part of a specific larger whole, to be in reciprocal relation with a specific larger whole, for actors to have the ability to act and take responsibility. The act of participating requires autonomy and awareness of interdependence of its parts. In participatory systems new processes of signification define human experience in merging on- and offline realities, including the ability to envision, imagine [2]. In the reciprocal relations perception of trust and security needs to be well designed for acceptance.

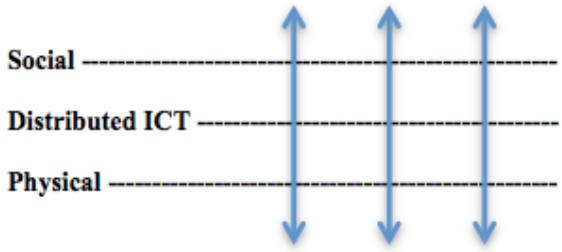
Large distributed ICT systems affect many processes of individual and societal developments. Driven by new technology and becoming successful in mostly in a trial and error manner, participatory systems have acquired power and agency. At first such systems predominantly function in communities of practice. Once successful they transgress to the commercial domain where large multinational corporations are driven by maximizing profit [3]. Particulars of systems design, software design, locality of data and the operations that are being executed with these data, are mostly opaque. Governance structures to balance power and offer transparency for participants are only partially in place [4]

All participatory systems are social-technical systems. Not all social technical systems are participatory. This paper proposes to distinct participatory systems from other systems and aims to sketch characteristics of such systems providing a framework for analyses and design with which the specific character of a specific participatory system can be identified, including the implications of this character for its participants. Empirical research needs to verify and falsify this framework.

The paper explores the concept of participatory systems. First it introduces characteristics of participatory systems in chapter 2. Chapter 3 focuses on how to enable participation and chapter 4 describes technology for participatory systems. In chapter 5 some key notions on governance of participatory systems are introduced and last in chapter 6 we discuss design methodology for participatory systems.

I. What is a Participatory System?

Participatory systems are defined as social-technical networked systems for which 3 levels of structures, networks and governance are distinguished that are interdependent and interwoven in the functioning of participatory systems [5].



- **Social:** refers to social, economical, political and cultural dynamics
- **Distributed ICT**: refers to technologies that enable large-scale distributed self-organising processes, information exchange, aggregation and clustering.
- **Infrastructure**: refers to physical networks and physical entities like windmills or cars for example that are part of participatory systems

Every participatory system has a mission in which next to the purpose of the system also a set of shared values is formulated. In a participatory system for energy for example, inhabitants of a neighbourhood agree to create an ecological safe environment. They build windmills and solar panels and create a smart grid in which they all participate. Distributed ICT facilitates the energy distribution in a variety of ways. They may agree to share different energy resources or they may agree to sell energy to each other. They may decide to adapt their behaviour to the amount of energy available or they may decide to buy energy from elsewhere or add batteries to their smart grid design.

When participating people accept the mission and the set of shared values of a participatory system. A participatory system is successful when it fulfils its mission and participants feel they have acquired assets (material or immaterial) as result of their participation in the system. The mission of a participatory system can initially be designed in a top down manner, but will evolve over time because bottom-up strategies and dynamics are essential in participatory systems. Individuals commit to the mission and values from out a variety of personal interests and purposes and these affect how a participatory system evolves over time. The neighbourhood may initially decide to share the energy, having invested together, but in later years with new inhabitants settling in, decide to create a monthly contribution or decide to set up a paying system for individual use.

Participatory systems offer people an experience of time, of place, of relations with others and offer possibilities to act. [6] For accepting responsibility dynamics of causality have to be clear. In the neighbourhood, which installed the smart grid, inhabitants need to be able to anticipate that there is enough energy to cook food for example. Individuals need to be able to anticipate consequences: the impact of an action, the feedback to this action and the understanding of the perception of the impact and feedback of one's actions. These inform people in creating personal trajectories through on- and offline merging realities, which are the result of interaction between the social layer, the distributed ICT and the physical layer.

The total of participant's trajectories defines how culture in a participatory system emerges. It drives processes of self-organization, adaptation and new developments in all three layers of the participatory system (physical, distributed ICT, social) As result groups and communities form, adapt, change and affect emergent dynamics in the participatory system. In a neighbourhood where people share responsibility for their energy resources social cohesion will be different than in a neighbourhood where people buy energy anonymously.

Participatory systems are more than the sum of their parts. In the case of the smart grid neighbourhood, citizens of the neighbourhood will need less energy together than counting up individual needs. And several neighbourhoods may decide to share as well, and this circle of sharing can be extended to cities, to countries and beyond. Human beings accept responsibility in consistent environments and will compartmentalize and fragmentize their radius of action in emerging and ever adapting patters of change in participatory systems. The many local interactions add up to the global behaviour of the participatory system, which cannot be deducted or inducted from individual behaviour alone.

II. Enabling Participation

Already in 1996 Malcolm McCullough writes: "How to operate technology is not enough; it might be better to ask *How to be* when using technology. If it were possible to summarize this psychology in a single word, that word would be 'participation'. (…) Psychologists and software designers use a wide variety of terminology to discuss participation: intentionality, focus, assimilation, cognitive guides, enactive knowledge, engagement, transparency, attention." [7].

The Merriam-Webster dictionary describes participation as the state of being related to a larger whole [8]. The 'being related' in this definition suggests that past, present and a future that can be anticipated are fundamental to participation. Systems are traditionally described in function, structure and behavior. The here proposed concept of Participatory Systems adds to this description the notion of 'human experience'. Human experience is defined as the (instant) reflection that results from being subject to events, emotions and sensations and understanding these in a larger framework of personal, organizational and historical perspective [9]. Designing for participation in systems is designing for human experience in and of systems. In the experience of being in reciprocal relation with a specific larger whole different on- and offline realities merge while including past, present and anticipated future dynamics of the participatory system.

In the era of ubiquitous computing with media and networks available at all times, new configurations of time, place, possibilities to act and new ways to be in relation are occurring. Millions of people are used to *being here* and *being there* at the same time. Presence research has been studying the phenomena for 'being here' and 'being there' for the last two decades [10]. Technology design, properties of physical and physiological perception, smart orchestration and dramaturgy to trigger imagination have all been subject to research and have resulted in a vibrant community that focus foremost on the individual sense of 'being there' in virtual worlds [11]. However, the concept of participatory systems needs a more sociological understanding of the sense of presence. It is assumed that having presence, being here and being there, is a requirement for participation in participatory systems. In such systems, between the social, the distributed ICT and the physical layer, on- and offline happenings merge in human experience [12].

Presence is essentially the capacity to strive for well-being and survival and it is a trade-off between different information and communication possibilities [13]. Sensations, emotions and complex feelings indicate in which direction well-being and survival can be found [14]. Systems can trigger sensations, emotions and feelings. In systems human presence is formatted in different editorial formats and protocols. Systems design needs to offer trade-offs that allow people to steer towards their own well-being and survival. Making trade-offs occurs and is designed in different configurations of time, place, actions and relations [15]. The making of trade-offs varies in different cultures, professional roles and in different generations, for which reason participatory design methodologies (design research, artistic research, serious games, simulations) contribute to the iterative process of participatory systems design.

Through interaction and transactions human beings integrate mediated realities in their day-to-day life in performing presence. Technology enables new perception of self and others presence. Smart visual, audio and tactile information affects how human beings perform presence and are able to act. Ameliorated perception of these smart virtual realities contributes to situational awareness and stimulates human (co-) presence [16]. Vice versa, smart systems are capable of detecting nuances in human presence and feed dynamics of the participatory system.

Current research to ameliorate human presence in participatory systems aims to make it possible for human beings to accept responsibility in complex network environments. In this research the notion of 'witnessing' is core. In being and bearing witness human beings negotiate trust and truth [17]. As result of being and bearing witness to each other, culture emerges. As result of being and bearing witness to each other in a specific context, people accept responsibility for the larger whole they are part of. Also large amounts of data can be processed real time offering 'third witnessing perspectives' [18] Technology facilitates new ways of witnessing in mediated and augmented realities.

Processes of engaging with a system, feeling safe to act and accept responsibility in a system, evolve over time. In this time a specific culture of a participatory system is emerging. People formulate and share experiences of/in reality through narratives, imagery and sound. Imagination is fundamental to this process. Language and shared concepts are established (levels in quality of contributions, netiquette, media schemata, power relations, graduated sanctions). Intervening cultural (and political) processes of 'unfreezing' and 'framing' change the solution space and affect people's sense of agency [19]. The experience of participatory systems (including the sensations/emotions/feelings it triggers in the many processes of interaction) reflects and defines a shared imagination in which values are expressed. Artistic research, design research, serious games and processes of co-creation explore shared imagination, values and understanding of human experience in participatory systems.

III. TECHNOLOGY FOR PARTICIPATION

Large scale distributed systems are characterized by processes of adaptation, emergence and self-organization. To be able to predict and anticipate emergent dynamics in a specific participatory system, simulations are created in which different dynamics of different values are constructed and explored. Such simulations inform analyses and design. Designing technology for participatory systems mandates design based on values:

- Designing for trust entails designing for transparency, security, integrity, privacy, identifiability, traceability, accessibility, proportionality, reliability, robustness
- Designing for engagement entails designing for interaction, presence, enactment, communication, awareness, co-creation
- Designing for empowerment entails designing for autonomy, self-regulation for human actors and automated systems, emergence;

All of these aspects have very strong implications for the design of technology. Such aspects are of particular importance in today's networked society in which networked technology is becoming ubiquitous. Focusing on individual and collective prosumer empowerment, information and communication technology are used to support human involvement. Smart agreements within energy communities, for example, are of many types. Membership, for example, mandates means for prosumers to discover each other on the basis of one or more criteria/values, to negotiate terms of membership, and means with which to enforce membership agreements. This mandates technology for negotiation (for example, reasoning within a context, matching and distributed search (distributed white pages), but also integrity.

Communities are formed on the basis of one or more shared (social/information/energy) needs, interests, intents, and preferences. Communities adapt as the context changes, as

social cohesion develops, as new (shared) goals and opportunities emerge, in energy generation, allocation and provisioning. To this purpose communities need to be able to make use of (energy) services that build on the smart (energy) infrastructure and distributed ICT. These services need to be both discoverable and accessible. For example, service agreements on energy provisioning and balancing need to be negotiated and monitored and enforced. Empowering individual and collective prosumers requires technology to enable such social structures to emerge [20].

Service Level Agreements between autonomous automated systems defined in the context of human interaction, in large scale distributed networks, provide a means for automated agreement that in turn can be automatically monitored decentrally. Robustness of networks capable of self-management, for example, is essential for system reliability. Adaptive, distributed group formation for system integrity, for local coordination of processes, is the basis for global management [21].

Multiple simulation platforms are deployed; specifically DSOL [22], AgentScape [23] and Symphony to design and explore the dynamics of such distributed systems. Simulation is of specific importance for the design of large-scale distributed participatory systems such as crisis management, energy markets, supply network management, sensor networks, cyber security, but also crowd-based systems, to explore and verify system characteristics.

IV. Governance and Participatory Systems

Both formal and informal structures of governance define human behaviour and dynamics in participatory systems. Coordinating, orchestrating and editing versus regulating, steering and control. Policies, regulations, rules, protocols, editorial formats and structures of support create possibilities to act and areas of responsibility. Different levels and positions of stakeholders concur with specific structures of management and governance. As result collective processes of mutual influence, decision-making and control on various levels are structured. Institutional and organizational power of policymaking and execution are defined by these dynamics.

The speed and scale of participatory systems challenge current structures of governance. In an instant a configuration of positions can change, a simple action can trigger millions of others. The new speed and scale of inter- and transactions is a major force to create and maintain large structures of self-efficacy and support. The new speed and scale are also fertile ground for abuse. Local, regional, national bodies of governance have little public domain to interact with multinational global companies. The global public domain is defined by complex politics and is hardly capable of orchestrating the global market. However, large-scale participatory systems become social and political players in their own right. Formats, methods and procedures for participation, orchestration of roles, responsibility and accountability, position determination, conflict resolution demand for new structures of governance for participatory systems. Participatory systems evolve over time, operate at grand scale and speed, and affect lives of participants potentially in fundamental ways.

For participatory governance coordination seems to be crucial. So far Service Level Agreements, are a way to facilitate local coordination. Another form is the Distributed ICT Auction, which permits anonymous trading as well. In the transition from ‘old’ to ‘new’ participatory systems, a sense of urgency is necessary for stakeholders to commit.

Current research focuses on designing large distributed systems in which people can accept responsibility. To this end two perspectives are core to the design process of large distributed participatory systems. First perspective is ‘global management for local coordination’. The second perspective is ‘poly-centricity’, in which 7 established design requirements are formulated for the governance and economy of each ‘centre’ [24]. Research for serious games is the vehicle to understand dynamics between lay people, experts and systems in which formal responsibilities and accountabilities are at stake [25]. Dynamics of participatory governance, both in distributed ICT and non-distributed ICT contexts need to be studied to explore what governance is possible and necessary under what conditions in which contexts. Top down grand designs, trial and error, step-by-step, internal, external, formal and informal governance dynamics should be explored [26]. Distinction needs to be made between participants who are interdependent and participants who can exit any time without facing any consequences.

V. Design proces of Participatory Systems

Designing participatory systems requires a new design approach, extending existing theories and models. Current insight is that participatory systems are driven by co-design and co-creation of social, technical and ecological systems. Characteristic of new design processes is that stakeholders are participants in the design process, engaged throughout. In the first phase, when mission and values of the system are defined, in later phases when identifying design spaces, in simulations to understand better the interaction between people and the network in the specific participatory system at hand, and in the final phase when the participatory system, its governance and the iterative process of redesign are initiated.

Theory and model of design are defined with three design spaces: (1) requirement design space, (2) design artefact design space, and (3) the design process design space. The results of design are the requirements it fulfils, the design process characteristics and the artefact itself [27]. The design of participatory systems, systems designed for adaptation, according to these models and this theory is currently on going, in particular with respect to design process characteristics.

Participatory systems are designed and emerge through learning processes of both the system and its participants through the process of its existence. Questions keep changing. It is an evolutionary design process. In the (re-) design of the

evolutionary process different tools are used at different moments in time: workshops, focus groups, questionnaires, creative methodologies, design research, artistic research, serious games, simulations and emulations. A design process for participatory systems necessarily includes five phases: (A) formulating mission and values, (B) identifying design spaces, (C) conceiving of conceptual design, (D) pilots/simulations/emulations, (E) roll out. In the evolutionary design process, next to function, structure and behaviour, human experience is leading. Insights from the arts, the social sciences and humanities are explicitly invited to contribute.

CONCLUSION

Exploring vision for participatory systems offers new opportunities for applied research as well as that it inspires fundamental research questions. The emphasis on human experience in participatory systems allows for a range of disciplines to contribute. The extensive iterative design processes offer in each phase of the design of participatory systems new challenges to solve. Future research aims to formulate a framework for participatory systems design for inspiring both analyses and design of human experience in a variety participatory systems.

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Inventory of design methodologies for participatory systems design in different phases of the iterative design process

A. Mission
Design process: KPI's and metrics
Design process: scenarios
Design process: norms and values
Design process: orchestration of commitment, rules and decision making of design process
Design process: research design
Design process: exit strategies and systems ending

B. Identifying design spaces
Systems design spaces
Value sensitive design
Presence Design
Design of trade-offs (YUTPA framework among others)
Design process: design for re-design (meta-design)
Design process: poly-centricity
Design process: artistic research
Design process: new technology

C. Conceptual Design
Design process: visualization
Design process: Interaction design
Design process: self-organization, coordination principles
Design process: participatory design
Design process: serious games
Design process: governance
Design process: business plan
Design process: define rules of engagement and decision making of participatory system

D. Simulation, Emulation, Distributed ICT
Design process: distributed ICT
Design process: simulation
Design process: emulation
Design process: testing

E: Rolling out Participatory System
Design process: orchestration engagement
Design process: governance
Design process: structure continuous redesign
Design process: exit strategy and system's end

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