Towards Decision Support for Participatory Democracy ♦

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Abstract

In many parts of the world there is a growing demand for participation in public policy decision making. This demand could be satisfied by the design and deployment of web-based group decision support systems to aid large groups of, possibly, non-sophisticated, users in participating in such decisions. After describing several mechanisms for participatory democracy, we provide a framework for decision support in that area and describe decision support functions that could be implemented in such framework. We illustrate the ideas with a specific system to support participatory budget elaboration through the web. Several practical issues are discussed alongside.

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1. Introduction

Information and communication technologies (icts) are influencing politics much as they have previously revolutionized business, education or the arts. The changes are affecting both our democratic institutions and democracy at large. They may also shape citizens' behavior, affect their learning about public policies and the politicians' interaction with the public.

The current models of democracy are mainly representative. At regular intervals, people elect representatives who take charge of making decisions, with little additional input from the citizens, until new elections. This practice has evolved into a political routine in which politicians hardly ever maintain substantial contacts with the citizens, except during election campaigns. The resulting disappointment with politicians and distrust about the political system (Bray and McLaughlin, 2005) manifests itself in low voting rates during elections and has lead to, what is generally termed, the 'democratic deficit' (Steffek et al., 2007).

The direct democratic model, typically associated with ancient Athens (Crick, 2002), may be viewed at the other extreme of the spectrum of democratic implementations. In such model, people are involved in almost permanent public decision making. However, at the implementation level the Athenian model had flaws from today's perspectives of direct democracy; women and slaves had no right to vote and many of the poorer men could not leave their work to attend meetings. It is therefore, estimated that only around 15% of the people living in Athens took actually part in the process (op. cit.).

Between the representative and the direct democracy, there is room for many intermediate models, each with a varying degree of citizen contribution and participation. Participatory democracy promises broadened citizen involvement and contribution leading to greater legitimization and acceptance of public decisions, greater transparency and efficiency in public expenditures, and greater citizens' satisfaction (Renn et al., 1995; Baierle and Cayford, 2002). This is not to say that there are no social and economic costs associated with participatory democracy, including the participants' myopic and short-time perspectives (Irvin and Stansbury, 2004). Nevertheless, there seems to be no better way to address the problems associated with the representation-based democracy other than through increasing citizens' involvement in decision-making. Participatory democracy emphasizes learning and encourages citizens to consider preferences of other participants and justify or modify their own preferences (Radcliff and Wingenbach, 2000).

Information and communication technology (ict) can improve participation processes by providing tools for the facilitation and support at the following levels of citizens' involvement and responsibility:

1. *Informing* is a one-way relationship between government which actively provides access to information and citizens who are able to use government services and form opinions (e.g., government websites and official gazettes);

2. *Consulting* is a two way relation of consecutive actions, in which government poses questions and formulates issues for consultation while citizens provide feedback (e.g.,

public opinion surveys);

3. *Participating* is a two-way relation of simultaneous actions of both the government and citizens engaging in the design of the process and content of policy-making. At this level the citizens have equal standing in shaping the discussion. However, the responsibility of the final policy (decision) rests with the government (e.g., consensus conferences and citizen juries); and

4. *Deciding* is the full partnership relation between government and citizens which, in addition to the activities from the three previous levels, includes involvement in policy decision (e.g., citizen-initiated referenda).

The first three levels comprise the oecd's Public Management Service analytical framework used in the comparative surveys and country case studies (Caddy and Vergez, 2001, p. 21). We added the forth level which corresponds to direct democracy or institutions in which citizens participate in all activities of the policy-making cycle. At this level, decision analytic techniques, methodologies and icts can provide participants with support throughout the process (Gregory et al., 2005; Grönlund, 2005).

This chapter aims at describing how such support can be implemented. We first review several of the standard mechanisms for participation, using the language of decision support. We then provide an overview of some of the ict tools used to support participatory democracy. Next we propose a common framework to support decision making in participatory democracy and describe practical issues in relation with such proposal, referring mainly to its viability and stressing that there is more in this approach than just providing large group decision support. We suggest the required support functions for participatory democracy decision support. We, then, describe how these ideas are implemented in parbud, a system to support participatory budget elaboration through the web. We conclude with discussion of issues related to the implementation of decision support for participatory democracy.

2. Theories, Processes and Mechanisms for Participatory Democracy

Support for participatory democracy should be grounded in the existing theories of democratic policy-making. Two classes of theories are introduced followed by the policy process and selected existing mechanisms (institutions) used in participatory decisions.

2.1 Social choice and democratic discourse

There are two competing school of thought on public involvement in decision-making (van Mill, 1996) which can be used to provide theoretical foundations for decision support for participatory democracy.

Theories of social choice view politics in terms of aggregation of individual preferences (Elster, 1997). Various models have been proposed all leading to participation in government

through voting and referenda. These theories deal with issues of democratic fairness and problems with rules regarding the majority choice. Arrow's (1952) impossibility theorem and McKelvey's (1976) proof for voters' intransitive preferences are examples of problems that the preference aggregation methods face. Procedures aiming at reducing these and other problems associated with preference aggregation involve preference modification leading, if possible, towards a consensus and focus on the participation process and its innate benefits, rather than the fairness of its results (Radcliff and Wingenbach, 2000; Dryzek, 2001). Some of the attempts at strengthening the role of the process with its purpose inasmuch possible being a consensus share much with the theories of democratic discourse, introduced below.

Theories of democratic discourse focus on the process and view politics as the transformation of preferences through rational discussion (Elster, 1997). Active deliberation and unrestricted discourse allow participants to arrive at consensus and achieve rational outcomes. According to Habermas (1994), Dryzek (1990) and others, the democratic discourse is based on three assumptions: (1) access for all citizens is free and open; (2) transformation of participants' preferences and objectives through debate is possible; and (3) decision legitimacy and approval can be achieved through reasoned deliberation.

Discourse is the process of the communication of reasons and justifications for claims and actions; its purpose is to seek a mutual understanding concerning the course of action. The discourse paradigm posits that open communication coupled with people's willingness to hear and understand leads to the convergence of individual preferences and, thus, to consensus. The obvious difficulties arising from the practical implementation of a democratic discourse model in very large groups led their proponents to suggest elections and voting (Habermas, 1994, p. 9). This, however, introduces problems similar to those with which social choice theories must cope.

The key difference between these theories is their consideration of *rationality*. Social choice has a minimalist and instrumental view of rationality (van Mill, 1996). What action is chosen depends on the participants' individual preferences, which are fixed, and which can and are measured using certain democratic institutions (e.g. a referendum). The individual preferences are then aggregated producing a result which reflects people's will (majority). The assumption of fixed preferences is important. Otherwise, they could not have been measured and aggregated. This does not imply that social choice theory does not allow for preference modification but that its institutions ignore it; they are designed to measure and aggregate. Making more than one measurement would introduce chaos and undermine the concept of rationality based on the preferred outcome.

Democratic institutions are designed to measure preferences at given points in time and they do not deal with the ways these preferences occur and are modified. Therefore, numerous other mechanisms (e.g., polls, political rallies and pressure group interventions) have been established to influence citizens and shape their preferences. These mechanisms precede but they are not the part of democratic institutions because of the assumption that preference aggregation is the sole requirement for process convergence.

Instrumental or substantive rationality is at the core of traditional decision analysis. It is concerned with the process of individual decision-making focusing on the construction of

decision attributes and alternatives and the specification of individual preferences. The process leads to the construction of a utility function or another scheme allowing for the selection of an optimal (Pareto-optimal) alternative. However, as Simon (1986, p. 215) notes: "In a substantive theory of rationality there is no place for a variable like focus of attention" nor is there place for interaction between the process of expressing and reflecting on preferences and preference values. These and other similar variables are in the realm of discourse or procedural rationality which posits that "the rational person … goes about making his or her decisions in a way that is procedurally reasonable in the light of available knowledge and means of computation" (op. cit., p. 211). The persons' rationality results from their engagement in the discourse process with other participants; they engage in an open and substantive discussion with the purpose of constructing a shared view. The preferences and low-level objectives are tentative and are formulated and reformulated during the course of democratic discourse.

Pure models of deliberative democracy require ongoing participation of citizens just like in ancient Athens. Modern propositions aim at addressing concerns of the democratic deficit and citizens' frustration with politics and politicians. The problem is that "deliberative democracy … remains on the face of it impossible" (Dryzek, 2001, p. 651). The cognitive effort and time required for decision-making and the inability to engage in any meaningful discussion with millions or even thousands of others render this approach infeasible. Solutions that attempt to alleviate this problem, include restricting deliberation to a few extremely important matters (Rawls, 1993); restricting the number of participants but making sure that those involved are representative (Goodin, 2000); and two-track deliberation in the public sphere and in the legislature (Habermas, 1996). In all these situations effective participation by citizens who may have no training in policy-making and insufficient knowledge about the problems at-hand is predicated by systems and tools that would aid and support them in the individual and group decision-making activities.

2.2 The policy making cycle

Democratic governance is a continuous cycle process comprising the following five stages (Dunn, 1994):

1. *Agenda setting* establishes priorities among the issues of public concern that requires a policy action or the change of a previous one.

2. *Policy analysis* aims at better understanding a public issue on the agenda: the problem is formulated and alternative policies are created in order to solve it. To do so, the facts are clarified and the interests and objectives of citizens and stakeholders are considered.

3. *Policy decision*: based in the previous analysis, a final decision is made and the chosen policy is fully specified.

4. *Policy implementation:* once a policy of action is selected, it is put into practice. At this stage the necessary public resources and regulations are used and created to make the policy operative.

5. *Monitoring* aims at continually evaluating if the implemented policy is producing the expected results, identifying if the policy should be changed or if new issues need to be considered in the agenda.

The level of public participation at each stage of the policy making cycle defines different democratic models. In the *representative* democratic model, the citizens choose representatives within a fixed period of time, those whose electoral promises better match their interests, who govern the society on behalf of the citizens and in accordance with what they understand is the public interest. Elected representatives take part in Stages 1 and 3, whereas civil servants and external expert advisers take part in Stages 2 and 4. Public participation is reduced to elections and opinion polls, mainly at the monitoring stage, to find about the satisfaction of the public with the running policies. Occasionally, the public may be consulted via referendum at Stage 3.
The *direct* democratic model proposes that the public should be directly consulted at the policy decision stage in almost every policy decision, and possibly in stages 1 and 2. Finally, the *participatory* democratic model proposes engaging the public at every stage in a variety of ways. It emphasizes public participation in Stages 1 and 2 of the policy making cycle, leading to final policy decision made in Stage 3 by the public and/or elected representatives.

There are two key aspects that characterize the scope and degree of participatory democracy: (1) participants, that is, those involved in the decision-making process, and (2) problems, that is, what type of decision making problem the participants decide upon. The number of decision-makers and the selection criteria for participants determine the scope: the more participants and the less restrictive the participation criteria, the more participatory the democracy is. Note, that in each case the administration is responsible for the implementation of the selected policy, creating the administrative procedures and infrastructures that allow the citizens to have access to the services and information concerning the implemented policy.

Social choice theories will typically be applied at Stage 3 of the policy making cycle, providing theoretical foundations for designing valid mechanisms for participatory decision making. Theories of democratic discourse can be applied to support public debate at the policy analysis stage. Thus, advocates of the direct model of democracy focus on social choice theories, whereas defenders of the participatory model are usually more interested in democratic discourse theories.

2.3 Some participation mechanisms

The rules that govern the selection of the decision-makers' and the decision process determine the primary participatory democracy mechanism. As we have mentioned in Section 1, there are four levels of the citizens' involvement (informing, consulting, participating and deciding) and with each level concrete democratic mechanisms may be associated.

We are primarily interested in the mechanisms used at the participating and deciding levels; they, include stakeholder workshops, citizen juries, consensus conferences, deliberative opinion polls, negotiated rulemaking, task forces and town meetings (Noveck, 2004; Rowe

and Frewer, 2005). We briefly describe some of them to gain insights and provide a basis for a general framework which is presented in Section 4.2. One should note that many of those mechanisms essentially refer to a very similar concept, e.g., consensus conferences, citizen councils, deliberative focus groups, citizen panels and citizen juries are different variants of the same participatory mechanism. There are five key types of mechanisms:

1. *Citizen juries* draw on the symbolism and practices of a jury in a court. The jury is made up of people usually selected at random from the target population. The jurors question experts who provide different perspectives on the topic, and produce a summary of their conclusions. This may be supervised by an advisory panel, composed of people with relevant knowledge and interest in the outcome, but who take no direct part in the jury deliberations. Members of this group subsequently decide whether to respond to, or act on, elements of the report.

2. *Stakeholder workshops.* A small group of participants who represent various interest groups is convened to examine an issue and discuss with politicians and administration. Such a group may be used to monitor the progress of the project and inform the community about new information concerning the project's implementation.

3. *Deliberative opinion polls* are a variant of opinion polls incorporating deliberative democracy principles. They aim at establishing a base of informed public opinion on a specific issue. They combine small-group discussions involving large numbers of participants with random sampling of public opinions: citizens are invited to take part at random, so that a large enough group of participants will provide a relatively accurate representation of the public opinion.

4. *Town meetings* are mechanisms of direct democracy at the local municipal and district levels. Open discussion and questioning of authorities may end with voting which is used to aggregate the citizens' opinions leading to biding decisions.

5. *Referenda* are consultative mechanisms of direct democracy in which citizens choose from the available options through voting, each vote having the same weight. Direct universal voting on issues via referenda has many advocates (Westen, 1998). However, they raise many political and technical issues (Uleri and Gallagher, 1996), including, the entitlement to call a referendum, the implications of the outcomes, the required majority[1] and the number of referenda on the same issue.[2]

The instruments mentioned above have been proposed, studied and implemented within the growing field of participatory democracy. Given their importance, it is perhaps surprising that there has not been yet a systematic approach to developing guidance on good practices

[1.] In the last referendum in Catalonia, for example, the turn out was 49.4% out of which 73.9% voted in favour, resulting in a decision being made by 36,5% of the census.

[2.] An example of this are the three referenda held so far in Quebec to try to obtain the independence of that Canadian province.

in this area. Furthermore, given the large number of different participation methods, there has been even less guidance on choosing which methods are most appropriate to a particular set of circumstances. A recent report by the Council for Science and Technology in the UK noted (CST, 2005) that despite many experiences with the government engaging in a dialogue with the public there is "lack of learning from experiences between and even within organizations"

The typical participation involves discussion during face-to-face meetings and the use of voting, frequently just by raising hands (Rios and Rios Insua, 2007). Such meetings can disadvantage people with poor communication skills. It has also proven difficult to involve the young and the poor. In terms of the ICT usage, the focus has been on discussion fora or other online discussion tools (Davies; 2007), and online pooling and voting tools (Krimmer, 2006). However, the problem is the lack of methodologies to identify and manage conflict and support joint problem solving. Decision support technology is usually not employed; no proper problem structuring tools are used, no formal quantification of citizens' preferences is undertaken, and no formal negotiation or group decision support tools are used, except for those based on voting. The following will discuss possible solution to changing the status quo.

3. Support for Participatory Instruments

The above and many other participatory mechanisms have been implemented in a variety of ways. Most frequently, ICT allow for their deployment on web and for seamless mechanism integration. In this section, we discuss some of the ICT-based systems and tools designed with the primary purpose of facilitating and supporting consultation and deliberation. Their purpose is primarily oriented on discussion facilitation and gathering and categorizing of citizens' opinions; they aid the activities of democratic discourse. Other systems, in particular, electronic voting are founded on social choice theories.

3.1 Online deliberation

Initial efforts to use ICT in participatory democracy were based on the ability of Internet to connect large numbers of people and help them communicate, and aimed at designing explicit or implicit implementations of democratic discourse theories.

Tools and systems for online participation and deliberation are based on group support systems (Jessup and Valacich, 1993) and meeting systems which belong to the computer supported cooperative work (Turoff and Hiltz, 1993). These systems have their roots in behavioral decision theory both at the individual and group levels. Early initiatives in online participation and deliberation activities were based on email-based discussion forums using listserv technology; one of the best known participatory democratic initiatives is the Minnesota electronic democracy project which began in August 1994 (Aikens, 1998). Later, they incorporated tools for public and private communication, agenda setting and process structuring, brainstorming and idea generating, selecting criteria and idea categorizing, topic aggregating and commenting, conflict identification and, even, voting. Examples of such systems include Facilitate (http://facilitate.com), GroupSystems (http://groupsystems.com)

and Meetingworks (http://entsol.com). These systems were initially developed for local area networks and then redesigned as online applications and web services. Their purpose is to facilitate decision processes undertaken by small distributed or localized groups, often with the involvement of a human facilitator or moderator.

A research project led to the design of the GRASS system (group report authoring support system, http://grass-arena.net); the prototype has been tested with three cases, including the deliberation on green gas effects and the simulation of an earlier discussion done in British Columbia regarding issues related to forests and forestry and undertaken by the BCFOR group using a listserv (de Moor and Aakhus, 2006). This initiative appears stalled and no work has been done since 2004.

3.2 Argumentation support

Argumentation support systems provide enhanced online deliberation tools such as discussion fora with support features for argumentation, helping users to argue in a dialectical manner (de Moor and Aakhus, 2006).

The debate is structured in a way that an inference mechanism, based on logical or probabilistic rules, assists users to arrive at agreed conclusions. It is assumed that participants are open to persuasion in order to reach a consensus regarding the facts, values and available science via argumentation. As mentioned the deliberative approach assumes that a decision regarding public conflict issues can be reached through rational argumentation. This requires that participants share a common general objective, which is not always the case, as there may be quite different individual views and perspectives and very strong positions. Thus, in practice, the conclusions obtained from the debate do not lead to a decision itself, although can be used as an input to make a final decision. Nevertheless, these systems are a good means to gathering ideas, for formation of public opinion and for problem understanding. Thus, they are useful before a referenda or whenever a public decision would be made by voting, as well as for citizen juries or in participatory decision processes based on decision conferences.

GeoMed (Geographical Mediation) is an example of an integrated system which provides Internet based support for collaborative spatial decision making, like that for environmental and urban planning (Karacapilidis and Pappis, 1997; Gordon et al., 1997). This type of planning involves many parties with diverse backgrounds, interests and viewpoints. GeoMed has three integrated components: (1) computer support for collaborative work; (2) a GIS viewer; and (3) a mediated issue-based discussion forum with argumentation support. Our interest here is in the argumentation model included in the last component. This model is based on an adaptation of the ZENO argumentation framework (Gordon and Karacapilidis, 1997) modified for collaborative decision procedures for the urban-planning domain.

GeoMed uses an issue-based information system (Rittel and Webber, 1973) which structures the discussion as a tree: the root represents an issue, in our context the decision to be made or goals to be achieved (e.g., which is the most appropriate location for an airport?). Participants propose and discuss solutions to this issue, arguing their pros and cons. Positions represent statements and are identified as basic discussion elements, belonging to

one of the following types:

- Alternative positions propose a solution to the issue.
- Arguments are positions for or against another position. Supporting arguments and counter-arguments allow the participants to voice their views regarding a particular position.
- Constraints are positions that represent the relative importance between two positions. They are used to express preferences and value judgment statements. Redundancy and consistency of constraints are checked.

The activation status of a position (alternative or constraint) depends on its sub-tree of active arguments for and against, as well as active constraints about the importance of these arguments. A position without active arguments is, by default, active. The status of a position can be computed in various ways: (1) A position will be active if there is at least one active argument supporting it, (2) if there are no arguments against it, or (3) the constraints can be used to weight the pros and cons of a position. In absence of active constraints, all the arguments of a position have the same weight. Active constraints increase the weight of its more important position and decrease the weight of its less important position. When the difference between the weights of its active supporting arguments and its active counter-arguments is not negative the position is activated.

The Zeno framework embedded in GeoMed uses the above difference among weights to aggregate pro and con arguments associated with an alternative as a score to recommend at the end of the discussion the alternative with highest positive score. Thus, in order to support group decisions, the ZENO framework has proposed the above scoring mechanism to compare feasible (active) alternatives.

3.3 Electronic Petition Systems

A participatory process may be triggered by citizens through a petition using icts for this purpose (e.g., http://epetitions.scottish.parliament.uk/). Citizens can submit a public petition providing information relating to the issues raised. The e-petitioning system enables the collection of signatures on-line, rather than just on paper, to support a petition (Macintosh et al., 2002). In this way, petitions become accessible to a potentially much wider audience, allowing a communication channel for participation alternative to the traditional one. Each petition has also its own online discussion forum.

- The functionality of the system allows citizens to create a petition, view open petitions, access additional information of a petition issue, join a discussion forum regarding a petition, sign a petition by adding name and address, and follow the progress of a petition once it has been submitted to the parliament. This initiative for public petitions allows citizens to participate in the agenda setting and policy formulation stage of the policy-cycle. The e-petitioning system supports the potential participation via Internet. Thus, this system provide a more effective and efficient version of the petition process. As mentioned above the system gathers signatures for

a petition of those citizens who are in favor of it. However, there is no possibility of signing against a petition.

3.4 Electronic Voting Systems

Internet voting systems have gained popularity and have been used for government elections and referendums in Estonia and Switzerland, with trials in many other countries. In Switzerland, where it is already an established part of local referendums, voters get their passwords to access the ballot through the postal service. Most voters in Estonia can cast their vote in local and parliamentary elections, if they want to, via the Internet. It has been made possible because most Estonians carry a national identity card equipped with a computer-readable microchip, which they use to get access to the online ballot. All a voter needs is a computer, an electronic card reader, their ID card and its PIN, and they can vote from anywhere in the world. Corporations and organizations routinely use Internet voting to elect officers and board members.

Systems used for e-voting include Opinions-online, http://www.opinions.hut.fi/introduction.html), a web tool to organize voting; Vote-pro (http://www.vote-pro.com) and 2ask (http://www.2ask.net) which is proprietary software; the VoteSecure Project (http://www.votesecure.org) which is open source or the freeware KOA System (http://sort.ucd.ie/projects/ucdkoa).

A key concern with e-voting systems refers to security. There are, however, cryptographic solutions that allow voters to verify that their vote is recorded and tabulated; to provide evidence of proving how they voted with a form of electronic receipt, signed by the voting authority using digital signatures; and to allow voters to present a proof how they voted to a third party, through a receipt with a randomly generated id.

3.5 GIS and participatory spatial decisions

Many decisions that involve citizens are spatial, that is, location problems with decisions regarding, for example, storage or disposal of radioactive waste, location of new facilities or expansion of the existing ones, or transportation. One of the key forms of decision support is via geographic information systems (gis), which, in its core is a computerized interactive map along with a database to store and manage spatially-referenced data.

- In their traditional mode of operation, GISs are seen as an impediment to participation and empowerment because they have been operated by trained decision makers using restricted databases, behind closed doors (Pickles, 1995). Making GIS tools, and their associated databases, available to the public is the prerequisite for placing all stakeholders on equal footing. The proliferation of Internet is contributing to make GIS tools accessible through the web, so that they can be used by citizens to develop understanding of the spatial consequences of the proposed projects and actions affecting their communities. As the public will need to effectively interpret and use these tools on the Internet, their interface design should be adapted for public use and technical jargon should be avoided.

- On-line GIS also enable users to link any amount or kind of data to a location on a map. Thus, in order to provide the spatial information necessary for a decision analysis, spatial knowledge and preferences can be collected and easily shared and distributed via participatory GIS tools. In multi-criteria decision making (Carver, 1991), both spatial and non-spatial attributes may be considered. GIS allow for displaying in a map the spatial consequences of the alternatives. For example, costs, pollution, servicing areas, affected areas, and revenue have all been successfully included in GISs.

- Concerning the type of public decision problems in which a participatory GIS may be used, we note that as spatial scale of a decision increases from the local to the regional and, ultimately, to the national scale the proportion of people willing to actively participate gets smaller (Kingston et al, 2000). We also note that the ownership and copyright covering some spatial data may be a disincentive to develop and deploy participatory on-line GIS solutions to local decision problems (Carver et al, 2001).

3.6 Systems based on decision analytic support

Increasingly the ubiquitous Internet and its various associated technologies allow devising a strategy of deploying generic decision support tools to aid groups in undertaking political decisions. So far, the most ambitious effort in that direction is the Decisionarium site at Helsinki University of Technology (Hämäläinen, 2003), which aims at somewhat sophisticated users of decision analysis tools. It provides tools and systems to support preference modeling through the construction of value functions, to support negotiation, voting and opinion polling, together with related e-learning materials. The tools are somewhat isolated and little attention is paid to such desirable support functions as decision making under uncertainty or process management facilities. Decisionarium have been used to support participatory environmental decision making albeit on a small scale (Hämäläinen et al, 2001; Mustajoki et al., 2004).

Although one possibility would be to deploy generic decision analytic tools complemented by simple communication tools, most of the applications of DSS to e-democracy are translation of those DSS that have been used to support civil servants to analyze technical issues that should be decided by the representatives or technical staff of the administration. In order to deal with different inputs from the participants, sensitivity analysis tools are added to facilitate the group elicitation of a common preference representation. An example of this trend is the Älgö experience (Danielson et al., 2005), in which a structured process involving all the interest groups was used by local authorities to engage the stakeholders in analyzing a problem that has been unresolved for several years.

A decision support tool for individual decision making, *DecideIT*, was used to incorporate the input of all the participants into the analysis and to support decision analysis using techniques from sensitivity analysis. This tool uses multi-criteria analysis and can handle numerically imprecise inputs using triangular distribution over intervals and comparative judgments. It allows the incorporation of different views and values into a decision model through intervals.

Finally, we could also think of developing specific tools aimed at supporting participation in particular public settings. An example here is PARBUD (Rios and Rios Insua, 2006), a system to support participatory budget elaboration through the web.

3.7 Software agents

A typical criticism to direct democracy, participatory democracy and, even, e-democracy in general is that people who are not professional politicians will not typically have time, skills and will to take part in the ensuing participation processes. We have already mentioned the low participation in Athens. Indeed, because of the potentially heavy demands of participatory democracy on the participants, in terms of time and cognitive load, a potential participant could delegate his intervention in the process to a software agent, which would act on his behalf in some of the tasks or in the whole process, possibly with consultations from the agent to the owner when in doubt. These agents can be used also to detect a relevant public issue in which its owner would be willing to participate.

In our context, the agent will have a built in utility function, elicited from the owner, to which the agent would invoke, whenever facing a decision, choosing among alternatives or voting among options. The agent would refer to its owner, whenever the decision is not clear enough, e.g., because two alternatives are too close in value, as determined via sensitivity analysis. It would also periodically revise such function depending on queries from the owner. The agent utility function would be based on an ample set of objectives and adapted to each problem, by retaining only those attributes that relevant to the problem at hand.

4. Decision Support Framework for Participatory Democracy

Participatory democracy requires that individuals understand the implication of their values and mechanisms to incorporate them in the decision analysis. The most advanced mechanisms of participatory democracy (e.g., negotiated rule making and town hall meetings) require that individuals make decisions. Because the participants may have different interests and objectives their views need to be identified, analyzed and compared, requiring both support for individual and group decision-making. Another important aspect of participatory democracy refers to providing support to a very large number of users, which might be very diverse in cognitive and decision making skills and styles. Gregory et al. (2005), without referring to ICTs, claim that decision analytic methodologies provide effective and valuable means for public policy deliberations. We explore here how such methodologies may be enhanced and implemented through ICTs.

4.1 Decision analytic methodologies for group decisions

From an operational point of view, French et al. (2007) suggest categorizing decision analytic methodologies for group decision support into five modes with somewhat fuzzy boundaries, which we adapt here for the purpose of participatory democracy support. We note that the focus is on modeling and supporting citizens as decision-makers in both individual and

group settings rather than analyzing, structuring and representing the decision problem(s).

GDM1. *Informed voting* implies working with each participant and developing their personal decision analysis to guide their choice. In the light of this, each participant votes and the group choice is made according to the votes. (Nurmi, 1987)

GDM2. *Explicit preference aggregation* involves eliciting each participant's subjective probabilities and utilities, combining the individual probabilities and utilities into group probabilities and utilities, respectively, to form the corresponding group expected utilities and choosing accordingly (Luce and Raiffa, 1957; French, 1985).

GDM3. *Joint evaluation* involves gathering the group together and facilitating discussion of issues. Through discussion group values are elicited directly with no intermediate step for individual members. Areas of disagreement are noted and explored through sensitivity analysis leading to a decision reached by consensus without formal voting (French, 2003).

GDM4. *Negotiations* involve the group interacting and discussing on how to solve an issue of public concern, while trying to reach an acceptable agreement (Raiffa, 2002).

GDM1 and GDM2 use procedures for aggregating individual's preferences; in the first ordinal preferences are used and in the second, cardinal preferences. A voting procedure is defined as a rule to combine individual's ordinal rankings in a complete and transitive order for the group. Although there are many possible voting rules, not all are considered to be acceptable. GDM1 studies criteria satisfied by specific voting rules as well as conditions under which a voting rule satisfying a set of reasonable requirements exists. It is known that while voting is quite well understood by participants and easy to use in very large groups, it can be subject to manipulation and, more importantly, it suffers from Arrow's (1951) impossibility theorem.

One way to alleviate the problems arising from the Arrow's result is to obtain more information about the individual preferences. Thus, instead of asking each participant to order alternatives, a GDM 2 procedure (also dubbed as arbitration) asks them for cardinal information about strengths of preferences. There are two possibilities from which the explicit aggregation of individual's preferences can be considered:

1. *Authority aggregation* is made from the perspective of a single "supra decision maker" (SDM) who has the authority to make the decision on behalf of the group and wants to consider the preferences of the group members in his decision analysis (Keeney and Raiffa, 1976). When a government agency has the legal responsibility and accountability for making a decision, but does want to take into account the views of citizens and stakeholders, then the assumption of a SDM becomes plausible; and

2. *Axiomatic aggregation* is used when the group shares the responsibility for decision-making. An equity-based axiomatic aggregating procedure may be used here to compute a group choice (e.g., the Nash solution). It requires that the group accepts the axiomatic procedure before its use.

Additive and multiplicative multiattribute preference models have been implemented in GDM2, using the preference values of the group members as attributes to evaluate consequences. These models for aggregation of cardinal preferences require interpersonal comparison of the individuals' strengths of preferences which are the cause of inconsistencies when axiomatic aggregation procedures are used. When the aggregation procedure is determined by an authority, the trade offs on the impact of a decision among the group members' values are made subjectively within the mind of the authority, defining valid interpersonal comparisons. Note that Nash (1950) solution is invariant with respect to positive affine scale transformation of the individuals' preferences, and, therefore, it does not require interpersonal comparisons. However, it requires determination of the individuals' disagreement values.

Models under GDM3 involve evaluating consequences directly by the group without considering individual evaluations, and, therefore, no aggregation is necessary. Thus, it is the group who should reach a consensus in an interactive way to determinate the group values.

The direct model of democracy and the social choice theories will favor modes GDM 1 and axiomatic GDM 2. However, although one can define algorithms in these two modes to move the numbers and votes around so that, ultimately, a group ranking is mathematically defined, if one examines the underlying assumptions, one can almost always find inconsistencies, typical of Arrow's theorem (1951). Authority GDM2 favors representative models of democracy where the entity responsible of the decisions is concerned in its analysis with the preferences of the members of society. It favors the design of mechanisms to extract a valid input from the public. Most decision analysts have proposed group decision support based on GDM 3 to guide public deliberations within the participatory model of democracy. GDM3 uses facilitated workshops or decision conferences in which the group discusses facts and values that should lead to a decision for the group. Disagreements are investigated using sensitivity analysis to focus the discussion on the differences of opinions that matter, aid participants to communicate and mutually understand their positions, and build consensual understanding. This process can be supported with elements of the democratic discourse theories described in section 2.1. GDM 3 assumes that while there may be quite different perspectives represented among group individuals, they share a general common interest and they are willing to reach a consensus. Finally, GDM 4 allows for a softer facilitated social process in which individuals bring very different interests and perspectives. This mode uses negotiation analysis principles and democratic discourse theories in order to design valid participatory processes to support the public within the participatory model of democracy.

All in all, we should briefly recognize a number of issues that participatory democracy brings in to standard group decision support. Some of them will be answered below. First, we have the issue of scalability. GDM1 and GDM2 are suitable provided that the mentioned analysis and elicitation are undertaken with the aid of a system. However, their contribution to the citizens' participation is limited. GDM3 and GDM4 were initially conceived for 5, 15, perhaps 50 participants' not for thousands or even millions that one may expect in a participatory process. Then, there is the issue of capability; these modes were designed for participants who have analytical inclinations. Note, however, that analytical sophistication

should be only expected on the facilitators supporting the processes. The idea therefore would be to create a user-friendly facilitator. A third issue refers to time and will, as there is a clear underlying assumption that users should have time and will to participate in the process, something not so frequent in modern times; we shall go back to this issue later by discussing participation incentives and delegating participation to software agents. Finally the issues of communication and coordination should be considered, It is not clear how decision analyses should be communicated to the general public. Coordination is even more difficult because no approaches are available that would be appropriate for such potentially large groups.

4.2 Framework

Various approaches have been proposed by researchers and various approaches have been used in decision-making. Many rely on the decomposition principle and use analysis as its method of inquiry, see e.g. French and Rios Insua (2000) or Raiffa (2002). Others rely on intuition, reductionism, holistic approaches, or partially- or ill-defined methods including "muddling through" or "garbage can" (Lindblom, 1959; March, 1978). It is clear that when dealing with a very large number of people coming from different backgrounds and having different education and professions, one cannot expect a uniform approach to decision-making. We must recognize this and, in general, allow participants to have access to decision aids that meet their needs and abilities. Regardless, in this chapter we use frameworks relying on the standard decision analysis cycle (French, 1986). We thus follow standard frameworks for policy as the five phase model of policy making cycle presented in Section 2.2, or Holtzman's (1989) three stage process (*formulate, analyze, decide*). To account for the involvement of multiple participants, we complement the standard decision analysis cycle with ideas and methods from negotiation analysis and group decision support (Raiffa, 2002).

As a consequence, we suggest a hybrid process that arranges a number of participation mechanisms throughout the deliberation process. In proposing the framework, we need to introduce the key roles that are involved in the activities comprising it, drawing on standard participation roles in applications. Specifically, three roles are distinguished in this framework:

1. The problem owner who decides to run the participatory process. It could be a group of citizens, the mayor of a city, or the president of a country;

2. The participants who take part in the process by providing their inputs; and

3. The facilitator who aid the participants in running the process.

Our framework is devised as a general approach, and, consequently, some phases might be eliminated in specific applications. Also, if necessary, we could cycle through one or several of the stages, until a decision is obtained for the group (Phillips, 1984). This framework shares the same decision analysis paradigm as one discussed in Section 4.1 so that it is conceived for analytically inclined participants. We shall, however, also discuss alternatives in which different participants may use different mechanisms.

1. *Preparation*. At this stage, the decision making problem is structured, identifying uncertainties, alternatives, their interrelations, constraints, criteria with which to evaluate consequences, and consequence assessment. The degree of sophistication of the structuring might go from a simple list of alternatives, perhaps with some constraints, to an influence diagram. Because of the assumed participants' tendency to think in myopic terms, we suggest that the problem owner, supported by technical staff, provides a seed document with an initial structure, afterwards discussed and consolidated by participants.

2. *Discussion and consolidation*. The participants discuss and consolidate the basic structure, aided by facilitators, to promote and enhance creativity. The agreed common structure will be used later on in the process. If uncertain aspects are involved, we suggest modeling these with the best available science.

3. *Individual problem exploration*. At this stage we extract the participants' preferences, e.g. in terms of their value or utility functions, depending on whether the problem is under certainty or under uncertainty. The participants may use this information to find out their preferred optimal alternatives and reasons for such choice. We would also use this information for later discussions and negotiations. If all participants obtain the same optimal alternative, we stop. If not, then the conflict needs to be addressed.

4. *Conflict resolution.* When several participants prefer different alternatives we shall need specific methodologies to integrate their values and problem solving techniques to reach a feasible group action. We could do it by arbitration, or negotiation and voting, or negotiation and arbitration, or just voting, with possibly the consecutive use of several of these approaches. For example, if we assume that we know the participants' preferences, an *arbitration* approach just needs the corresponding algorithm to compute the chosen arbitrated solution based on some equitable criterion (Thomson, 1994). A shortcoming of this approach is that these solutions could be seen as imposed; an advantage is the possibility of mitigating the stress produced by the presence of a potentially very large pool of participants discussing advantages and disadvantages of various alternatives. Instead of arbitration, we could use *negotiation.* Though there are various generic schemes, negotiations essentially consist of a process in which alternatives are iteratively offered, until one of them is accepted by a reasonable percentage of participants. Otherwise, no offered alternative is globally accepted. If negotiations end up in a deadlock, we may solve it through arbitration, mentioned above, or through voting. Again, we could appeal to numerous voting schemes (Brams and Fishburn, 2002). As mentioned, alternatively, we could directly move on to *voting,* but this might have the shortcoming as we do not motivate sufficiently deliberation among participants.

5. *Post-settlement*. If the outcome of the previous scheme is obtained through negotiation or voting, it could be the case that it is socially unacceptable, i.e. this outcome is dominated in a Pareto sense. Therefore, participants should try to improve it in a negotiated manner, through a negotiation scheme designed to converge to a nondominated alternative, which is better than the outcome obtained previously.

Note that the information obtained at stage 3 would be useful not only to compute the

participants' optimal alternatives, but could be used also to evaluate alternatives offered through the negotiation phase, to vote being better informed and, finally, to check whether our outcome is dominated and, consequently, start at stage 5. One possible comment is that participants may be reluctant to make public the information concerning their preferences. We assume in this design that the participants will provide this information to a secure and trusted intermediary, in a framework that may be called FOTID (full, open and truthful intermediary disclosure).

There may be many different decision making styles and analytical sophistication among participants. Therefore, we could conceive an alternative framework. Phases (1) and (2) would be essentially the same allowing the construction and manipulation of problem representation, solution generation and consequence assessment, with facilitated discussions among participants. Phase (3) would allow the manipulation of the representation by individual participants in order to better understand the problem and the implications of their judgments; these could involve sophisticated modeling with value functions and also less sophisticated methods as goal setting or just debating with other participants. Phase (4) would entail the construction and manipulation of the representation by the group, allowing sophisticated negotiation methods using value functions as well as simple methods like those based on debating the pros and cons of options in a forum and voting on options. Phase (5) would entail, in this case, exploring whether the outcome may be improved.

Some of the stages could be implemented in a virtual environment, whereas others could be based on a physical environment. It is interesting at this point to analyze in such context a specific case study in which one of us was involved in, concerning the development of the current Madrid regional research plan (2004-2007)[3] Through it we may show how some of the above stages are repeated, some are skipped and how various participatory mechanisms are implemented through electronic or physical means.

In 2002, the Government of Madrid started designing its new research plan through a participatory process. (*Preparation)* In a first stage, several focus groups were created around vertical (Mathematics, ICT, Energy, Nanotechnology, etc.) and horizontal topics (internationalization of research in Madrid, large infrastructures, etc.) Each focus group included around twelve persons (researchers, businessmen, etc.) lead by a chairman. The discussion was facilitated by two persons, one leading the group, the other recording the session, and ideas were generated ideas during a one day session. The chairman was in charge of producing a seed document published on the web and discussed through an Internet discussion forum by all focus groups, and consolidated again by the chairman (*Discussion and consolidation 1)*. Then each focus group convened physically to produce a final consensual document which included strategies and actions concerning the corresponding topic (*Discussion and consolidation 2)*. The whole list of documents was then published on the web to be discussed over the Internet by anybody in Madrid who was interested and finally consolidated by the chairmen (*Discussion and consolidation 3)*. The final document was then assessed from the technical and economic perspectives by the Research Directorate (*Problem*

[3] See http://www.madrimasd.org/queesmadrimasd/pricit/default.asp

exploration), voted and approved by the Government of Madrid (*Conflict resolution 1)* and submitted to the Parliament who voted and approved it with some amendments (*Conflict resolution 2)* and published as a Regional Law. No *post-settlement* was undertaken.

5. Support Functions in Participatory Democracy

Decision support and DSS have been devised to aid individuals and groups both in conflict and non-conflict situations. Participatory democracy or decisions made by very large groups of highly diverse persons introduces additional challenges that dss and its various incarnations in the past have not considered in sufficient depth. In this section, we briefly discuss selected issues which need to be addressed when one considers designing and implementing systems to support participatory democracy.

5.1 Information, access and presentation

An efficient use of the available technology should address the issue of how to provide citizens with relevant information in an understanding and accessible way. Technologies which can contribute to alleviate this issue are search engines, adoption of xml standard to facilitate searches (Rubio and Rios Insua, 2007), tools to merge documents in a collaborative way (Lourenco and Costa, 2005) and statistical tools to transform data into information among others.

If we want to design valid participatory processes we need to guarantee that participants are informed in a non-biased way before making a decision or contribute with their input. If we provided them with enormous quantities of raw data from which information can be extracted, we will need to provide them also with suitable statistical tools. Otherwise, raw data would not be very informative, and, even, might be misunderstood and misused within decision making processes. *Better access to information does not necessarily imply better knowledge,* (Sartori, 2002). We should also pay special care to the way the information is provided and displayed to the citizens, to avoid manipulations. We should note that when people decide on their own how they want to be exposed to information, then they may choose to attend only to those sources that support their previous opinions. However, to be able to judge properly it is necessary the challenge others arguments and give contrasts. *If I only listen to those of my tribe, if I can decide not to listen to the discrepancy, my decision is made beforehand,* (Sunstein, 2001). Therefore, some control in the information to which participants are exposed may ensure that they receive all the adequate information from which they will compose their judgments.

We have assumed here that once we provide citizens with the tools engaging them in a participatory process, they will access and use those instruments in a universal and equitable way. However, participants do not always have access or the necessary skills to use these ICT based instruments. The term *digital divide* has been used to describe the fact that the world can be divided into people who do and people who do not have access and the capability to use these technologies Therefore, there is a real danger of incorporating in participatory processes nearly the same people all the time, and isolating others including the most vulnerable population. In such a case, the process will lack sufficient legitimacy due to the

unrepresentative participation of the population and the input obtained from this process will not be valid, even if the participatory process is appropriate from a theoretical point of view. Once the accessibility issue is resolved, the question would be how ICT can be used to enable wider participation, and support those citizens who lack the skills to use them.

Indeed, it is far from clear that untrained users interacting with web-based participatory support tools will understand the cognitive tasks that face them. Hence neither may the system inform their judgement and understanding nor may their inputs inform the policy making process. With training, as can be provided within organisations, these cognitive issues may be overcome. However, in our context, there is less opportunity to provide prior training in the use of the tools and the citizens' interactions may be neither effective nor well founded. The design of the human computer interface should be done within a wider socio-technical context, with particular reference to youth and the elderly, and their use of ICT at home. Grima and Rios Insua (2007) propose to address these problems with the design of simple and easy-to-use graphical user interfaces.

We should also consider how to alleviate the resistance of people who will think that their power or comfort decrease with the implementation of a participatory process. In the worst case scenario the people who perceive these initiatives as disturbing might try to sabotage them.

5.2 Communication

Citizens participate in decision-making activities either indirectly, through their representatives, or directly. ICT extends the ability of participation from "same-place, same-time" to "any-place, any-time". At the same time the communication bandwidth which can be provided with ICT-based computer-mediated communication (CMC) is much narrower than in face-to-face (F2F) communication.

Various media are available for CMC including video, voice, sound, email, instant messaging, SMS, bulletin boards, shared workspaces, virtual reality spaces, and so on. An important issue in communication support is to select the appropriate communication channels to the participants.

Research on media richness theory may help us answer this question. This theory suggests that richness in these communication media can be determined by the degrees in availability of instant feedback, capacity to transmit multiple cues (e.g. body language, voice tone, and inflection), natural language support, and personal focus. Thus, face-to-face (F2F) communication has the highest media richness degree, whereas synchronous CMC has higher media richness than the asynchronous mode.

However, experimental research suggests that it is not always beneficial to provide the highest media richness degree. Certain media works better for certain tasks than others and effective management should consider matching a particular communication medium to a specific task and to the richness degree required by that task (Daft et al., 1987; Suh, 1999). For example, Ocker et al. (1998) studied four modes of communication support: F2F, synchronous distributed CMC, asynchronous distributed CMC, and combined F2F-

asynchronous CMC. They found that the combined F2F-asynchronous mode yields better performance in idea generation tasks than any other mode. This may indicate that F2F meetings combined with asynchronous communication support (e.g. discussion board) may be appropriate for idea generation tasks such as agenda setting, while the asynchronous communication support may be appropriate for decision making tasks such as voting on policy alternatives.

There is an extensive amount of experimental studies on the effect of CMC, but not all of them found significant differences and some of them resulted in conflicting outcomes (Fjermestad and Hiltz, 1998/1999). This indicates that the existing knowledge should be interpreted carefully considering the context. In addition, in participatory public decision making processes, not all participants may use the same communication mode – for those who attend the meeting, it may be F2F-asynchronous, but for those who did not attend the meeting, it becomes just asynchronous. Such heterogeneous situations open a new venue of CMC research.

5.3 Support for individuals

When an individual prepares for public participation in democracy, he should first think about what he likes, wants, and aspires to, as well as what he considers to be fair. Secondly, he should gather information about the public issues, the feasible courses of action and their expected consequences. Individuals can explore and analyze the expected consequences of different strategies in complex problems through scenario construction and simulation tools. Thirdly, if possible, find about the needs, preferences and aspirations of the others and, finally, identify the potential conflict and its degree.

We may advise individual participants about how they should behave to shape public decisions that concern them as close as possible to their interests, given their beliefs about how others might behave. When advising an analytically oriented party, we may use subjective expected utility models to analyze the problems. In such a case, a utility function representing the participant's preferences should be elicited. Preference elicitation procedures require time and effort from the advised participant but it allows finding the participant's most preferred action in a decision problem. Should we want to provide support for holistic oriented individuals, we could use case based reasoning as an alternative to the logic of consequence, in order to recommend them an action to be used in a recognized situation.

In democracy there might be many decisions that may affect an individual and in which he will not have the time to participate actively. As described in Section 3.7, in such case, software agents could help individuals with the automation of certain decision tasks and information searches, reducing the cognitive load associated with active participation.

5.4 Support for interest groups, coalitions

When individuals face public settings, they may be interested in searching for others with similar interests. This would open the possibility of defining a common strategy or trying to lobby the government or other interest groups. When a very large amount of people is in the

public arena, coalition formation might become difficult. Individuals interested in creating a coalition could use software agents that help them identifying people with similar interests in order to invite them to join the coalition. In this process, formed coalitions should be also identified so that interested individuals can join them. Another possibility, in case the individuals disclose their preferences to a neutral intermediary, would be to use statistical clustering techniques to identify groups with similar preferences and put them in contact through a forum or a distribution list.

Note that, in such a case, coalition formation is problem-dependent, because it is based on the individuals' preferences regarding the creation or modification of a policy associated with a specific public issue. Thus, individuals will join coalitions based on a specific public issue rather than join a political party that will not be able to support the interests of all its supporters in all public issues. Coalitions act strategically to pursue a common interest in a specific issue. This makes coalition to act jointly for the problem solution it prefers. Coalitions empower their members as they can reach more belonging to the coalition than by themselves. In case coalitions enter in the negotiation arena to try to settle a public issue, coordination between internal and external negotiations would also require support.

5.5 Facilitation, coordination and mediation

Process support is critical to the improvement of the productivity of individual and group work. Wide differences among the participants in their interests, knowledge, cognitive abilities and skills, cultural, education and other characteristics may make purely computer-based support insufficient and ineffective.

Facilitation may impact relationship development, participation, issue-based conflict, interpersonal conflict, negative socio-emotional participation as well as satisfaction and quality of the group decision (Miranda and Bostrom, 1999). There are various models of the facilitator. Facilitation may be performed by the internal leader of the group, just a member of the group, an external leader, or even by a system. The facilitator may focus on interactions or content facilitation. Facilitation may be restrictive or flexible. A facilitator may also provide training on the system and the process. In any case, solving socio-emotional issues is an important role of the facilitator (Kelly and Bostrom, 1998). In terms of timing of intervention, a facilitator may engage in activities before, during, and/or after the meeting.

In the environment of F2F group meetings supported by a system (so called decision-room), the facilitator typically provides technical support such as training and answering questions as well as process support. In this case, the role of the facilitator is critical because the facilitator promotes effective use of the system. In the synchronous distributed environment, the role is simpler because the technical support function is usually not provided by the facilitator.

In the asynchronous distributed setting, which is of most interest in this application field, the role of a facilitator can be more complex. First, a meeting in the asynchronous mode may last days, weeks, or even months. In addition, interactions of participants may happen whenever it is convenient for them and messages sent by a participant may be received by other participants in a different order. Further, because participants have more freedom to work

individually and interactions are less frequent and immediate, coordinating participants may be much harder (Tung and Turban, 1998).

Turoff et al. (1993) suggest four types of coordination methods:

1. Parallel coordination allows approaching the problem independently;

2. Pooled coordination extends the parallel one by the participants producing an outcome according to a standard procedure such as a vote;

3. Sequential coordination requires the participants to undertake problem-solving in a sequential manner; and

4. Reciprocal coordination requires that changes be made by one participant (sub-group) to necessitate other participants to re-consider their decisions.

It has been argued that a group supported by the synchronous communication mode typically uses a self-imposed sequential method of coordination, because the group uses agendas which force participants to go through the process step-by-step.

When the asynchronous mode is used, coordination mechanisms should be more explicitly considered. For sequential coordination, the agenda should be defined and enforced. For reciprocal coordination, frequent communication is required in order to let individuals reconsider earlier activities and make the necessary adjustments. For pooled coordination, there should be a signaling mechanism to indicate that individual approaches should be finished and the standard procedure should be started (Tung and Turban, 1998). Considering the nature of the communication mode and difficulty in group coordination, we expect that system facilitation or system-aided facilitation will play a crucial role in the asynchronous distributed environment.

5.6 Knowledge and expertise

The role of experts is to provide relevant information for risk assessment, assess the likelihood of uncertain events, modeling dependence relations among uncertain variables, evaluation of economical consequences and so on.

When uncertain aspects of the problem are considered, the Bayesian approach is often the most appropriate. In the Bayesian approach, probabilities are interpreted as measures of subjective beliefs rather than long-run frequencies to be estimated from data. They are particularly important when probabilities cannot be determined from historical data. Thus, this approach requires reliable probability assessment methods to extract knowledge from experts to be expressed in probabilistic terms, taking into account the psychological heuristics that experts use in forming these judgments and the potential for biases. Formal procedures have been developed to address these difficulties (Keeney and von Winterfeldt, 1991). One problem is that for many uncertainties there might not be sufficient evidence for scientists to agree on a common judgmental probability distribution modeling such variable. In such case, the opinions of several experts diverge. It, then, raises the question of how to

combine or aggregate these expert opinions to form a consensus probability distribution to be used as input in the model. The Bayesian approach to this problem (Morris, 1977) is based on Bayes' rule, but requires difficult assessments. In practice, there are still many complex modeling challenges and questions about the effectiveness of various combination procedures (Clemen and Winkler, 1990; French and Rios Insua, 2000).

Formal models for dialectical argumentation can be used to aggregate expert knowledge in a consistent manner when it is distributed and not individually sufficient to prove particular hypotheses (Hitchcock et al., 2001). These frameworks help to understand the logical implications of scientific knowledge and the arguments concerning the consequences of a policy of action. As an example, Risk Agora is a deliberation system which allows for modeling and support of scientific debates in the risk domain (McBurney and Parsons, 2000 and 2001). Its initial focus was on providing support for discussions about the potential health and environmental risks of new chemicals and substances, and their appropriate regulation. The authors have drawn on Habermas's theory of communicative action to define types of speech acts appropriate for such discussions.

5.7 Trust and confidentiality

Suppose that we have built in the above functionalities within an implementation of our framework in a web-based system supporting *e*-participatory processes to the satisfaction of the problem owner and the facilitator. We would still need to gain trust from the participants using the system and the professional politicians whose role would have undoubtedly changed. Issues relative to easy access, fair representation, the digital divide (Norris, 2001) and the potential for hijacking of an *e*-participation process by a pressure group are relevant as well.

The first issue to be addressed would be to trust the system and the correct implementations of the algorithms and methods. One clear possibility would be to develop the system in the open source model, so that they can be openly verified by third parties, to ascertain that all opinions are taken into account in the manner announced by the implemented framework.

The second important issue refers to confidentiality so that our opinions, preferences and votes remain only known to ourselves, so as to avoid pressures potentially derived from preference profiling. The FOTID framework described above may be used effectively for that purpose with the aid of a recent plethora of powerful cryptographic methods.

6. PARBUD: A system to support e-participatory budget elaboration

As an illustrative example, we shall describe in this section how our framework is specified for the case of participatory budgets and how such framework may be implemented in a system.

Two or more mechanisms may be applied to problems which are both complex and of

particular interest to the citizens. One such problem is participatory budgeting; traditionally it has been managed through a mix of direct and representative participation (Souza, 2001). One of the known and successful examples is participatory budgeting in Porto Alegre (Santos, 1998).

Participatory budgets are set up along well defined rules which regulate the number of delegates to each body, the role of public authorities, the prerogatives and powers of a participatory budget council, the discussion fora, the voting rules; and the amount assigned in the participatory budget process to be allocated. The budget process is usually organized by territorial sectors and themes (e.g., culture, education, social services and safety) and implemented according to three levels, based on the degree of participation and the tasks to be carried out:

1. The first level is local. It involves small groups made up of streets or neighborhoods. Participants discuss specific problems and the necessary interventions. Finally, priorities are established and representatives are designated to defend them at the next level.

2. At the sector or theme level, assemblies discuss the strengths and weaknesses of the first-level results, define global priorities for sectors, and designate delegates to become members of the participatory budget council.

3. The third level is the participatory budget municipal council. Its members are designated for a period of time and represent sectors and themes, as well as the municipal executive, public services and associative movements. The council supervises participation and ensures communication between the municipal administration and the participatory pyramid.

We view participatory budgets as a resource allocation procedure in which citizens have to decide how to spend the available resources by selecting several projects from a list. Each project has an estimated cost and is evaluated by each citizen in view of multiple criteria. The total cost of the selected projects must be smaller or equal to the maximum budget limit. There could be other constraints which restrict a feasible selection of projects. For example, there could be several projects concerning a new hospital and only one should be chosen or there could be a project that can be selected only if another project is selected. The citizens represent a wide variety of interests and they may prefer different projects. Therefore, sheer selection will be inadequate requiring debate leading to an agreement. We describe here how we have adapted the framework presented in Section 4.2 to support the participatory elaboration of a budget.

1. *Preparation*. The problem is structured before a final list of proposals is identified. We structure the criteria with which to evaluate projects, prepare an initial list of projects together with their associated costs and technical features, and identify constraints. This phase is fully conducted by technical staff who will post the resulting document.

2. *Discussion and consolidation*. Participants are allowed to propose new projects and criteria, or eliminate some of them, supervised by a facilitator, to consolidate the final list of proposals and criteria. This phase also provides an opportunity for participants to better

understand the general features of the problem. This may be undertaken through moderated discussion fora or through physical meetings.

3. *Individual problem exploration*. We elicit the participants' preferences to guide and provide analytical support during the process.

4. *Conflict resolution*: Negotiation. Participants are allowed to make offers and debate them through a supported discussion forum. Participants are allowed to accept or reject each proposed offer by voting in favour or against it. The offer with highest percentage of acceptance among participants will be implemented if this percentage is sufficiently high. Otherwise, no offered budget will be globally accepted.

5. *Conflict resolution: Voting*. If the negotiations fail, a voting session allows for determining a budget. We use approval voting over the projects to compute the winning budget, however, other voting schemes could be used.

6. *Post-settlement*. In the case that a potential budget obtained through voting or as agreement in the negotiation would be jointly improvable, participants should try to improve it in a negotiated manner. We use a modification of the balanced increment method (Rios et al. 2005) to support such negotiations, as it is designed to converge to a nondominated budget.

This approach supersedes the standard participatory budgeting methodology, which roughly speaking, consists of Phase 2, in which participants prepare a list of initial proposals, and Phase 5, in which participants vote over such list. By including Phase 1, before 2, we mitigate the issue of a too myopic vision of participants. By including phase 5 after Phases 3 and 4, we allow participants to vote with a better knowledge of the voted options. By including phase 6, we provide a mechanism to verify whether a potential list of projects is socially suboptimal.

We have adapted our proposed methodology to support groups in the elaboration of participatory budgets and implemented it through the web in PARBUD. This system assumes the role of the facilitator, as a neutral external helper, who gathers confidential information from participants allowing a FOTID framework: the system will know the participants' true preferences, which will not be disclosed to counterparts. The FOTID framework enables, e.g., to detect whether the outcome is dominated and, in such case, improve it in a negotiated manner, suggesting efficient and equitable budgets for possible acceptance based on knowledge of the participants' preferences and some concept of fairness, until one is jointly accepted. Rather than using physical meetings, allowing for alternative generation and voting, PARBUD promotes virtual meetings in which participants discuss the problem and explore the consequences through an integrative methodology, confidential revelation of preferences to the system, and negotiation for conflict resolution.

7. Discussion

We conclude this chapter by discussing several practical issues concerning decision support

in participatory democracy. First of all, as may be seen from a number of governmental initiatives and pilot projects, and the interest in the field from a number of consulting companies and software vendors, e-participation processes will soon be standard practice in our political life, and the decision support community could contribute a lot in this. Our purpose here was to suggest a robust framework that may accommodate many current participatory processes and relies on decision support tools. Our experience with small groups of quantitatively sophisticated users involved in specific problems like participatory budgets has been very rewarding. But we still need to test our proposal with large groups of non-sophisticated users on general problems. To do so, we would need first to develop the corresponding generic architecture, possibly based on web services, which would include, among others, problem structuring, voting, negotiating, arbitrating, problem exploration, preference modeling, debating.

An important issue is that these tools are aimed at promoting and increasing participation, but will they achieve it? If people are not currently participating in democratic processes, will the introduction of these tools increase the interest for participation? Barrat (2006) discusses these questions in depth. After all, modern times are characterized by a hectic life in which citizens might find little time to participate. Note, however, that we are not mentioning that we should be involved in all decisions that affect us, but rather that there would be occasions in which we could be interested in taking part, as in determining budget priorities. In this relation, it might be of interest to study what type of incentives could we use to promote citizen participation. As we mentioned, trust in systems is also an important issue in the field. For this, it might be a great opportunity to develop open source systems.

All in all, we hope to have illustrated an emerging and exciting application area in which the DSS community has a lot to say.

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References

Aikens, G. S. (1998). "A Personal History of Minnesota Electronic Democracy, 1994." *Journal of Government Information* **25**(1): 1-9.

Arrow, K. J. (1951). "*Social Choice and Individual Values*", New York, Wiley.

Baierle, T. and J. Cayford (2002). "*Democracy in Practice: Public Participation in Enviromental Decisions.*" Resources for the Future.

Barrat, J. (2006) "A preliminary question: is e-voting actually useful for our democratic institutions? " In R. Krimmer (ed) *Electronic Voting 2006,* GI-Edition.

Brams, S. and P. Fishburn (2002). "Voting Procedures", In Arrow, Sen, Suzumura (eds) *Handbook of Social Choice Procedures,* vol 1, 173-206, Elsevier

Bray, J. and D. McLaughlin (2005). "Getting to Ground: Democratic Renewal in Canada". Crossing Boundaries Papers. D. McLaughlin. Ottawa, The Crossing Boundaries National Council**:** 29.

Caddy, J. and C. Vergez (2001). "Citizens as Partners: Information, Consultation and Public Participation in Policy-making", OECD.

Carver, S. (1991). "Integrating multi-criteria evaluation with geographical information systems." *International Journal of Geographical Information Science* **5**, 321–339.

Carver, S., A. Evans, R. Kingston and I. Turton (2001). "Public Participation, GIS, and cyberdemocracy: evaluating online spatial decision support systems." *Environment and Planning B: Planning and Design* **28**, 907-921.

Clemen, R. and R. Winkler (1990). "Unanimity and Compromise among Probability Forecasters". *Management Science,* 36, 7, 767-779

Crick, B. (2002). "*Democracy: a Very Short Introduction*". Oxford, Oxford University Press.

CST (2005). "Policy through Dialogue: Informing Policies based on Science and Technology". London, Council for Science and Technology.

Daft, R. L., R. H. Lengel, L. K. Trevino (1987). "Message equivocality, media selection, and manager performance: Implications for information systems." *MIS Quarterly* **11**(3): 355-366.

Danielson, M., L. Ekenberg, Å. Grönlund and A. Larsson (2005). "Public Decision Support – Using a DSS to Increase Democratic Transparency," I*nternational Journal of Public Information Systems* 1, 3-25.

Davies, T., B.S. Noveck, (2007) "*Online deliberation: Design, Research, and Practice*" CSLI Publications/University of Chicago Press.

de Moor, A. and M. Aakhus (2006). "Argumentation support: from technologies to tools." *Communications of the ACM* **49**(3): 93-98.

Dryzek, J. S. (1990). "*Discursive Democracy*". New York, Cambridge University Press.

Dryzek, J. S. (2001). "Legitimacy and Economy in Deliberative Democracy." *Political Theory* **29**(5): 651-669.

Dunn, W. (1994). "*Public policy analysis: an introduction*", Prentice Hall.

Elster, J. (1997). "The Market and the Forum: Three Varieties of Political Theory". In J. Elster and A. Hylland. Deliberative Democracy: Essays on Reason and Politics. Cambridge University Press**:**

103–32.

Fjermestad, J. and S. R. Hiltz (1998/1999). "An assessment of group support systems experiment research: methodology and results." *Journal of Management Information Systems* **15**(3): 7-149.

French, S. (1985) "Group consensus probability distributions: a critical survey". *Bayesian Statistics 2*. J.M. Bernardo, M.H. DeGroot, D.V. Lindley and A.F.M. Smith, North-Holland 183-201.

French, S. (1986). "*Decision Theory: An Introduction to the Mathematics of Rationality*" Willey, Chichester.

French, S. (2003). "Modelling, making inferences and making decisions: the roles of sensitivity analysis." *TOP* **11**(2), 229-252.

French, S. and D. Rios Insua (2000). "*Statistical Decision Theory*". London, Arnold.

French, S., D. Rios Insua and F. Rugeri (2007). "e-Participation and Decision Analysis", *Technical Reports on Statistics and Decision Sciences*, U. Rey Juan Carlos.

Goodin, R. E. (2000). "Democratic Deliberation Within." *Philosophy and Public Affairs* **29**(1): 81-109.

Gordon, T., N. Karacapilidis, H. Voss and A. Zauke (1997). "Computer-mediated Cooperative Spatial Planning". In H. Timmermans (eds) *Decision Support Systems in Urban Planning*. E & FN SPON: 299-309

Gordon, T. F. and N. Karacapilidis (1997). "The Zeno argumentation framework". *Proceedings of the 6th international conference on Artificial intelligence and law*. Melbourne, Australia, ACM Press: 10-18.

Gregory, R. S., B. Fischhoff and T. McDaniels (2005). "Acceptable Input: Using Decision Analysis to Guide Public Policy Deliberations." *Decision Analysis* **2**(1): 4-16.

Grima, C. and D. Rios Insua (2007) "Designing a general architecture to support e-government", *Technical Reports on Statistics and Decision Sciences*, U. Rey Juan Carlos.

Grönlund, Å. (2005). "DSS in a Local Government Context–How to Support Decisions Nobody Wants to Make?" In M. A. Wimmer EGOV 2005 LNCS 3591. Berlin, Springer.**:** 69-80.

Habermas, J. (1994). "Three Normative Models of Democracy." *Constellations* **1**(1): 1-10.

Habermas, J. (1996). "*Between Facts and Norms: Contributions to a Discourse Theory of Law and Democracy*", MIT Press.

Hämäläinen, R.P. (2003). "Decisionarium - Aiding Decisions, Negotiating and Collecting Opinions." *Journal of Multi-Criteria Decision Analysis* **12**: 101-110.

Hämäläinen, R.P., E. Kettunen, M. Marttunen and H. Ehtamo (2001) "Evaluating a framework for multi-stakeholder decision support in water resources management", *Group Decision and Negotiation*, **10**(4): 331-353.

Hitchcock, D., P. McBurney and S. Parsons (2001). "A framework for deliberation dialogues". Proceedings of the 4th Biennial Conference of the Ontario Society for the Study of Argumentation. Windsor, Canada.

Holtzman, S. (1989). "Intelligent Decision Systems". Reading, MA, Addison-Welsey.

Irvin, R. A. and J. Stansbury (2004). "Citizen Participation in Decision Making: Is It Worth the Effort?" *Public Administration Review* **64**(1): 55-65.

Jessup, L. M. and J. S. Valacich, Eds. (1993). "*Group Support Systems: New Perspectives*". New York, Macmillan.

Karacapilidis N. I. and C. P. Pappis (1997). "A framework for group decision making support systems: Combining AI tools and OR techniques" *European Journal of Operational Research,* **103**: 373-388.

Keeney, R. L. and H. Raiffa (1976). "*Decisions with Multiple Objectives: Preferences and Value Trade-offs*". New York, John Wiley and Sons.

Keeney, R.L. and D. von. Winterfeldt (1991). "Eliciting Probabilities from Experts in Complex Technical Problems", *IEEE Transactions on Engineering Management*, 38, 191-201.

Kelly, G. G. and R. P. Bostrom (1998). "A Facilatator's General Model for Managing Socio-emotional Issues in GSS Meeting Environments." *Journal of Management Information Systems* **14**(3): 23-44.

Kingston, R., Carver, S., Evans, A., Turton, I. (2000) "Web-based public participation Geographical Information Systems: an aid to local environmental decision making" *Computers, Environment and Urban Systems* **24,** 109 – 125.

Krimmer, R. (2006). "*Electronic Voting*". Proceedings of the 2nd Workshop on Electronic Voting (ed). Bonn.

Lindblom C. E. (1959). "Muddling Through", *Public Administration Review*, **19**(2): 79-88.

Lourenço, R. and J. P. Costa (2005). "Incorporating citizens' views in local policy decision making", *Decision Support Systems:* (to appear).

Luce, D. and H. Raiffa (1957) "*Games and Decisions*", New York, Wiley.

Macintosh, A., A. Malina, and S. Farrell (2002) "Digital Democracy through Electronic Petitioning". In W. McIver and A. K. Elmagarmid (eds.) Advances in Digital Government: Technology, Human Factors, and Policy. Boston/Dordrecht/London: Kluwer Academic Publishers: 137-148.

March, J. G. (1978) "Bounded Rationality, Ambiguity, and the Engineering of Choice", *The Bell Journal of Economics*, **9**(2): 587-608.

McBurney, P. and S. Parsons (2000). "Risk Agoras: Dialectical argumentation for scientific reasoning." In C. Boutilier and M. Goldszmidt (eds.) Proceedings of the 6th Conference on Uncertainty in Artificial Intelligence (UAI-2000).

McBurney, P. and S. Parsons (2001). "Intelligent Systems to Support Deliberative Democracy in Environmental Regulation." *Information & Communications Technology Law* **10**(1): 79-89.

McKelvey, R. D. (1976). "Intransitivities in Multidimensional Voting Models and Some Implications for Agenda Control." *Journal of Economic Theory* **12**(3): 472-482.

Miranda, S. and R. Bostrom (1999). "Meeting Facilitation: Process versus Content Interventions." *Journal of Management Information Systems* **15**(4): 89-114.

Morris, PA (1977) "Combining expert judgments: a Bayesian approach". *Management Science,* 23, 7, 679-693.

Mustajoki, J, RP Hämäläinen, and M Marttunen (2004) "Participatory multicriteria decision support with Web-HIPRE: a case of lake regulation policy", *Environmental Modelling and Software* **19**(6): 537-547.

Nash, J.F. (1950) "The bargaining problem", *Econometrica*, 18, 155-162.

Norris, P. (2001). "*Digital Divide. Civic Engagement, Information Poverty, and the Internet Worldwide*", Cambridge University Press

Noveck, B. S. (2004). "The Electronic Revolution in Rulemaking." *Emory Law Journal* **53**(2): 433-519.

Nurmi, H. (1987) "*Comparing Voting Systems*", Dordrecht, Holland: D. Reidel

Ocker, R., J. Fjermestad, S. R. Hiltz and K. Johnson (1998). "Effects of four modes of group communication on the outcomes of software requirement determination." *Journal of Management*

Information Systems **15**(1): 99-118.

Phillips, L. D. (1984). "A theory of requisite decision models." *Acta Psychologica* **56**, 29-48.

Pickles, J. (1995). "Representations in an Electronic Age: Geography, GIS, and Democracy". In J. Pickles (eds), *Ground Truth: The Social Implications of Geographical Information Systems*. Guilford Press, New York**:** 1-30.

Radcliff, B. and E. Wingenbach (2000). "Preference Aggregation, Functional Pathologies, and Democracy: A Social Choice Defense of Participatory Democracy." *The Journal of Politics* **62**(4): 977-998.

Raiffa, H. (2002). "*Negotiation Analysis: the Science and Art of Collaborative Decision Making*". Cambridge, Mass, Harvard University Press.

Rawls, J. (1993). "*Political Liberalism. The John Dewey Essays in Philosophy*". New York, Columbia University Press.

Renn, O. (2004): "The Challenge of Integrating Deliberation and Expertise: Participation and Discourse in Risk Management" In T. L. MacDaniels and M.J. Small (eds.) *Risk Analysis and Society: An Interdisciplinary Characterization of the Field* Cambridge University Press, 289-366.

Rios, J., D. Rios Insua, E. Fernandez and J.A. Rivero (2005). "Supporting participatory budget formation through the web". In M. Böhlen, J. Gamper, W. Polasek and M.A. Wimmer (eds.), *E-Government: Towards Electronic Democracy*, LNAI 3416, Springer, 268-276.

Rios, J. and D. Rios Insua (2006) "PARBUD. A system for e-participatory budget elaboration", *Tech. Rep*., U. Rey Juan Carlos

Rios, J. and D. Rios Insua (2007) "A framework for participatory budget elaboration support", *Journal of Operation Research Society* (to appear)

Rittel, H. W. J. and M. M. Webber (1973). "Dilemmas in a General Theory of Planning." *Policy Sciences* **4**(2): 155-169.

Rowe, G. and L. J. Frewer (2005). "A Typology of Public Engagement Mechanisms." *Science Technology and Human Values* **30**(2): 251-290.

Rubio, J.A. and D. Rios Insua (2007) "NegoML. An XML schema for negotiation analysis support", *Tech. Rep.*, U. Rey Juan Carlos.

Santos, B.S. (1998). "Participatory budgeting in Porto Alegre: toward a redistributive democracy", *Politics and Society*, vol. 26, no. 4, pp. 461-510.

Sartori, G. (2002) *¿Qué es la Democracia?,* Taurus.

Simon, H. A. (1986). "Rationality in Psychology and Economics." *The Journal of Business* **59**(4): 209-224.

Souza, C.U. (2001) Participatory budgeting in Brazilian cities: limits and possibilities in building democratic institutions, *Environment and Urbanization* **13**(1): 159-184.

Steffek, J., C. Kissling and P. Nanz (2007). "*Civil Society Participation and Global Governance: A cure for the democratic deficit?"* Palgrave Macmillan.

Suh, K. S. (1999). "Impact of communication medium on task performance and satisfaction: an examination of media-richness theory." *Information & Management* **35**: 292-312.

Sunstein, C.R. (2001) *Republic.com,* Princeton University Press.

Thomson, W. (1994). "Cooperative models of bargaining". In R.J. Aumann and S. Hart (eds.), Handbook of Game Theory, North-Holland, Vol. II, Chapter 35, 1238-1277.

Tung, L. and E. Turban (1998). "A Proposed Research Framework for Distributed Group Support Systems." *Decision Support Systems* **23**: 175-188.

Turoff, M. and S. R. Hiltz (1993). "Distributed Group Support Systems." *MIS Quarterly* **17**(4): 399-416.

Uleri, P. and M. Gallagher, Eds. (1996). The Referendum Experience in Europe. London, MacMillan Press.

van Mill, D. (1996). "The Possibility of Rational Outcomes from Democratic Discourse and Procedures." *The Journal of Politics* **58**(3): 734-752.

Westen, T. (1998). "Can Technology Save Democracy?" *National Civic Review* **82**(2).