# Group Decision Support for spatial planning and e-government

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***Abstract:*** *The presented work investigates process models for participatory spatial decision processes, especially focusing on IT-supported procedures. Results of this work are process patterns according to different classes of problem complexity, accompanied by operational instructions for conducting the procedure, and requirements for the supporting software tools. The aim of this paper is to explain the need, development and application of an integrated discourse system, which can be applied to participative spatial decision processes in e-government. It describes two experiments in the field of e-participation, from which schemes of IT-support for participative spatial decision processes are derived.*

***Keywords:*** *group decision making, multi-criteria analysis, mediation, voting, GIS*

## Introduction

"Space determines people's perception of the world and ultimately determines what we call 'local' and 'global'. The effects of space, place and locality are identified as key factors determining public interest in decision problems" [5]. People local to a particular problem or issue will, by the very virtue of their geographical position, be (in the main) interested enough to get involved or at least express a considered point of view if questioned. As scale increases, a smaller proportion of the population affected will be interested enough to seek involvement such that, at national scales, the proportion of the interested population is pitifully small, even though the absolute numbers may be quite large [14].

Developments in ICT (Information Communication Technologies) and the change towards a European new economy in the last decade has given favourable ground for the rapid growth of a new Information Society in which new forms of democracy have started to take place. The European Commission fosters the implementation of new forms of e-government according to principles of subsidiarity, transparency and public participation. New tools are offered as useful support for spatial planning and decision making. Geographic Information Systems (GIS) perform reliable information management and analysis when spatial dimension plays a substantive role in the understanding of given phenomena and forecasting possible scenarios. GIS alone cannot solve all the problems in a planning process, but its integration with other ICT tools seems to offer the digital infrastructure for developing decisional process in the Digital Age [4].

Social science and GIS are coming together to support participatory approaches and the social implications [5]. In its traditional mode of operation, behind closed doors and operated by trained decision makers using 'restricted' datasets, GIS actually works against participation and empowerment. On these grounds GIS has often been criticised as being an elitist technology and one that merely enhances existing power structures [20]. Making GIS and appropriate datasets available to the public over the Internet, however, provides at least the potential to resize this situation by placing all stakeholders on an equal footing. This may ultimately help moving public participation further up the so called “participation ladder” past the rung of restricted participation [5].

The aim of this paper is to explain the need, development and application of an integrated discourse system, which can be applied to participative spatial decision processes in e-government. It describes two experiments in the field of e-participation, from which schemes of IT-support for participative spatial decision processes are derived.

## E-government and participative spatial decision processes

E-Government is one of the ten priority areas of e-Europe. E-Europe is an initiative which aims at building an “online ground” to develop a new economy mainly driven by the Internet. These objectives play an important role in fostering public participation and transparency and a wider diffusion of e-government actions [8].

We speak of *e-government* when public agencies redesign their workflows to make better use of ICT. In the business world, it has long been understood that the potential benefits of modern Information and Communications Technology (ICT) can only be fully realized when existing business processes are re-evaluated and, where necessary, "re-engineered". *E-democracy*, according to this view, is nothing less ambitious than political process re-engineering, to reform democracy by taking into consideration the possibilities and risks of modern ICT. Thus e-democracy is a special case of e-government where the workflows affected are the core governance functions of government. It is the challenge of *e-participation* to achieve sustainable development with greater participation of interested parties and with more efficiency. Processes of innovation, if they shall lead to sustainable solutions, must be open, clear and fair. They must be designed so that everyone, persons involved, affected or interested, can contribute their issues in the most effective way. Action spaces must remain open, development options must be recognizable and usable.

The European Commission fostered the trend towards democratisation of decision making, within the challenge of the European institutional reform, by using new technology [7]. Impulses from theoretical discussions on urban planning strengthen the role of participation in urban planning. Combining this development with the options computer- and network-based technologies offer promises to improve the citizen satisfaction with the results of planning procedures [18]. Advantages of computer-aided decision processes are equity, transparency and comparability. Surely the decision itself is still based on human preferences, but it could be much better informed. In computer-aided decision processes the outcome is an informed high-quality decision.

## Developing IT-support for e-participation

Spatial decision making is a complex task. It requires a combination of competencies and software: decision support systems (DSS), computer-supported cooperative work tools (CSCW), group decision support systems (GDSS) and geographic information systems (GIS).

CSCW software enables people to collaborate through shared workspaces, to communicate via electronic messages or forums, and to cooperate through workflow systems or less rigid groupware. Key issues of CSCW are group awareness, multi-user interfaces, concurrency control, and heterogeneous, open environments that integrate existing single-user applications. CSCW is often categorized according to a time/place matrix [22], using the distinction between same time (synchronous) and different time (asynchronous), and between same place and different places (distributed) [21]. While asynchronous or distributed work must be supported through the Internet or other telecommunication networks, face-to-face (same time, same place) meetings may be enhanced by synchronous meeting support and conferencing systems. Applying web-based software in face-to-face meetings is rather unusual.

Group-decision processes and negotiation processes constitute very complex human activities. Improving their understanding justifies multidisciplinary studies based on cognitive psychology, organizational science, sociology, political science, etc. Furthermore, the development of computer-based support tools for these activities is rooted not only in communication/information technologies and OR/management science models, but also in human and organizational behaviour studies [6].

Complex decision-making processes deal with the problem of choice. Having elaborated a set of options, the goal is to choose one that meets the criteria of the decision makers best, or else to rank the options. DSS model decision making through decision trees, multi-attribute utility models, belief networks and influence diagrams [3]. GDSS support groups in decision making, especially to collect and structure ideas, concepts, issues, options or other categories. Some tools allow the participants to vote between options. Advanced tools provide a more structured model, notably the IBIS model for issue-based argumentation [15]. IBIS offers a semantic labelling function supporting a kind of inference [9].

Spatial decision-support systems (SDSS) emerged from the co-evolution of classic DSS research and from research in geospatial or geographic information systems (GIS). A SDSS can be defined as "an interactive, computer-based system designed to support a user or group of users in achieving a higher effectiveness of decision making while solving a semi-structured spatial decision problem" [16].

The role of participatory GIS is to help minimise conflict and arrive at decisions that are acceptable to the majority of stakeholders through consensus-building approaches based on awareness of the spatial implications of a decision problem [5].
It is a crucial problem that GIS technology itself is highly complex, which allows effective use only by specialists. Additionally one has to understand GIS as a socially constructed technology, including not just hardware and software but also the practice, laws, organizational arrangements, and knowledge that are necessary for its use [11].

Maps have been used predominantly as presentation media either to display the results of spatial decision analysis or to inform about the location of decision options. The use of maps as analytical tools in spatial decision analysis has hardly been explored. GIS present maps on different layers and can perform various spatial analyses on their database at the level of simple algorithms. Normally this does not reach the level of analysis performance provided in DSS. Jankowski, Andrienko and Andrienko [12] argue that a better integration of maps and multi-criteria decision making tools through data visualisation can improve the understanding of decision situations, and consequently lead to better outcomes of the decision making process. They propose to achieve such an integration through an interactive and dynamic visualisation of both, criterion and decision spaces.

For complex spatial decision problems a combination of group decision support, decision support and geographic analysis, a kind of “GDSGIS” is required. It combines the performances of GDSS and GIS with internet-based groupware.

In order to obtain such a “GDSGIS” for complex spatial decision processes in e-government and planning, the aim of the experiments to be described in this paper was to explore possibilities of an integrated discourse system. The integrated discourse system used for the experiments provides moderated and structured discourse as well as GIS and DSS features. It combines the two systems, Zeno and CommonGIS, developed by the Mediation Systems team (MS) and the Spatial Decision Support team (SPADE) of the Fraunhofer Institut Autonome Intelligente Systeme (http://www.ais.fraunhofer.de/).

Zeno features user and group management, protected communication sections for structured discourses, and process control instruments for the moderator. Support for discourse awareness and voting are in preparation. Zeno sections contain networks of articles, representing for example discussions, rationales or idea maps. The articles and their links can be labeled according to configurable ontologies. The articles may have a title and a note, attached documents and links to resources on the web, they can be topics or responses [23].

CommonGIS is a geographic information system that improves the understanding of decision situations through an interactive and dynamic visualization of both, criteria and decision spaces. It features interactive manipulation of geographic maps and multi-criteria analysis of spatial objects. CommonGIS allows voting by ranking or classifying options, and to analyze the results with all its instruments [1].

The integrated system Zeno® + CommonGIS facilitates spatial decision processes, map-centred discourses as well as decision making. It provides support in questions of location planning, site-selection and localization. The system targets planners, municipalities, public sponsors, real estate companies, developers, city-marketing, consulting agencies, logistics and goods traffic. While both systems are already used stand-alone for e-participation and GIS and decision support, as for example during an e-participation in the city of Esslingen [17] or the participative school project “Naturdetektive” [2], the integrated system is momentarily evaluated in role-plays.

## The role-play approach

The system is evaluated in an experimental environment that is similar to an “online mediation laboratory”. The aim is to experience the factors at work in a real situation but without the potentially devastating consequences. Experiments were accomplished to investigate requirements for the integrated groupware GIS system. The experiments are conducted according to the “role-play” action-research approach [26]. Action research provides an opportunity to bridge theory with practice, allowing to solve real-world problems while contributing to the construction of new knowledge. The role-play approach is a challenging research method, regarding its weak reliability. Nonetheless it is a feasible approach, especially because of its cross-dimensional usability. The approach serves the purpose of investigating process models for participatory procedures. Additionally the role-play will be a test area for the software, which will be continuously adapted by the corresponding software developers. Thus the action-research method conduces not only process modelling but also software development and testing. This is a unique interdisciplinary methodological dimension for both the research approach and the software development.

Two out of four planned experiments are already completed. The parameters of the role plays vary from experiment to experiment. The first experiment mainly set the basics for structuring spatial group decision making. The second brought further results in improving the model structure especially in the context of a complex ontology of task, space and discourse.

## The "Wallis" role-play

The first experiment was named "The Wallis Experiment", since the task was to select one out of forty locations in the Swiss region of Wallis [25]. The experiment was set up as a two day lasting mediated decision process, combining face-to-face and online sessions. Each of the eleven participants had the same role status. The outcome of the experiment is a combined process model, which integrates the standard mediation phases [10] with standard decision support (figure 1).

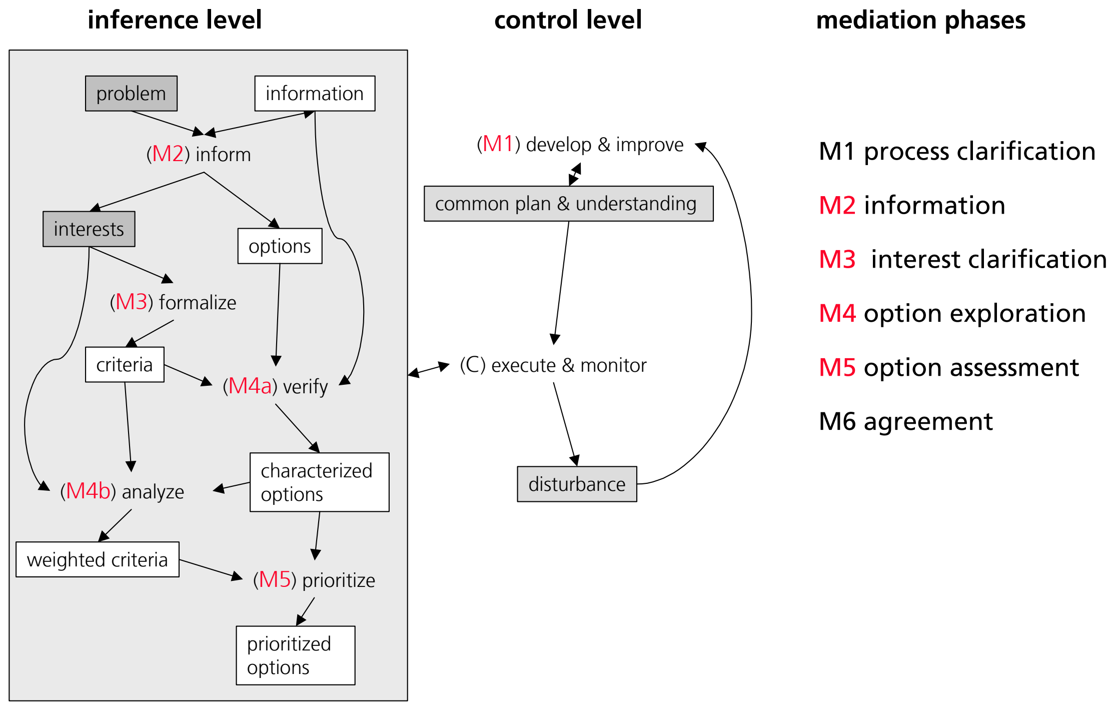


*Figure 1: The Wallis Model*

Figure 1 shows the Wallis model. Decision support tools assume a particular reasoning model. Criteria and options must be collected and the options must be characterized in terms of the criteria. The criteria are explored by comparing them with respect to all weighted criteria and the options are assessed, for instance by assigning priorities. This single user approach must be extended for group decision making, because the criteria and options may be controversial (c.f. the dark boxes in the diagram). A group would rather start from the problem, then develop interests and options, and then formalize interests as criteria. Figure 1 provides a matching between decision making actions and the mediation phases (M2), (M3) and (M4). Phase (M4) has to be split into two actions. First the *criteria must be verified (M4a),* that means each option must be checked whether and how it satisfies each criterion, and then the *options can be analyzed (M4b)* and compared with respect to the criteria. Meta-level activities are located at a separate control-layer.

The model is applicable to simple site-selection problems. The whole process was examined on the possibilities of IT-support, and a procedure/media as well as a media/tool matrix were developed. Recommendations for the selection of media and tools for each action in the model were formulated (see table 1).

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| **Invitation & pre-information on process**: Invitation to the role playing, descriptions of the tools to be used, a short introduction to mediation and information about skiing places in Wallis with web links had been available online in a Zeno workspace some weeks before the face-to-face-meeting. This kind of information on a website is surely helpful to prepare and to support mediated group decision making.<br>**Develop & maintain plan (M1):** Computer-mediated communication (CMC) can improve or impair cooperative behavior. In Wallis, all steps concerned with developing and adapting the plan were carried out face-to-face. A SMART board may help to develop the plan, and for later references, the plan should be documented electronically. A plan, as illustrated in figure 2, is a sequence of actions (from the model in figure 1) together with a combination of media and tools (from the table in figure 4).<br>**Gather information (M2):** Traditional forms of information gathering are expensive in terms of time and material. Print material has to be collected and analyzed before it is be sent to other group members by mail or is presented in a demonstration event (or several expert events). Gathering information is very well supported by web-based tools, including shared workspaces (Zeno) and web-based interactive exploration tools (CommonGIS).<br>**Formalize interests through criteria (M3):** Moving from informal, possibly hidden interests to formal criteria is an important step and requires the agreement of all participants. This step can be prepared concurrently using a structured communication forum, and might be completed face-to-face using the SMART board.<br>**Characterize options in terms of criteria (M4a):** This action is well supported by CommonGIS if suitable thematic data are available. Otherwise, participants have to search the web or other information sources, or delegate this task to experts. The results of web searches can be collected and discussed in Zeno, and then be transferred as new thematic data into CommonGIS.<br>**Explore options with respect to criteria (M4b):** The effort of formalizing criteria and checking them for each option is well awarded by the powerful interactive analysis capabilities of CommonGIS. Especially when the number of criteria and/or options is large, CommonGIS facilitates and accelerates decision making dramatically.<br>**Assess options (M5) / Execute & monitor (C):** Public voting is a questionable instrument, because it favors position-taking. Anonymous electronic voting, which allows to express priorities, can elicit differentiated opinions, and advanced software allows to analyze the results in a way that opens potentials for compromises. Electronic voting can be applied less reluctantly and is a powerful means for accelerating the process.<br>**Execute & monitor plan (C):** Disturbances have to be treated with priority. To detect them, all active communication channels must be observed. For this purpose the mediator should have a team of expert assistants. Disturbances should be handled in the medium where they arise, or else on the most effective channel (verbal communication in the case of Wallis).<br>Asynchronous structured communication forums support concurrent work, even on different actions. Applied in face-to-face meetings, this increases efficiency compared to necessarily sequential verbal contributions. The gain is even greater if disturbances can be handled concurrently without interrupting other parallel work.<br>Face-to-face caucusing is tedious and obscure. If performed instead in a discussion forum under pseudonyms or anonymously, this process becomes very transparent and engaging. |

*Table 1: Recommendations for selection of media and tools [25]*

### The “Call A Bike” role-play

The second experiment, “Call A Bike” (CAB), was a negotiation about a combination of possible locations for bike rental stations, where people could rent bikes by getting the electronic key-code by cell phone [24]. The experiment was set up as a four week project, involving three face-to-face meetings bridged by online phases. It was moderated during face-to-face meetings as well as during online phases. All eight participants had a different role status. The outcome of the experiment is an elaboration of the former “Wallis” process model, regarding both the complexity of the task (site-selection vs. demand satisfaction through facility allocation) and the complexity of the discourse structure (same role status vs. different role status). Due to the use of a new version of the groupware platform, it was possible to consider the discourse ontology during online phases (figure 2). Each Zeno section has its own discourse grammar (i.e. set of labels for articles and links). Every section can be inspected in different views: as a timeline, as topics, as their expansion into threads, as a table of subsections, and more. It is possible to link articles in Zeno to places on the map and, vice versa, access discussions about geographic objects from the map. For spatial exploration and voting the location-specific criteria, constraints and attributes can be transferred into CommonGIS and filled with values for each location. The users can visually compare and analyze the locations and how they fulfill the criteria.
A practical outcome of the experiment is an online demonstration of the process [19].

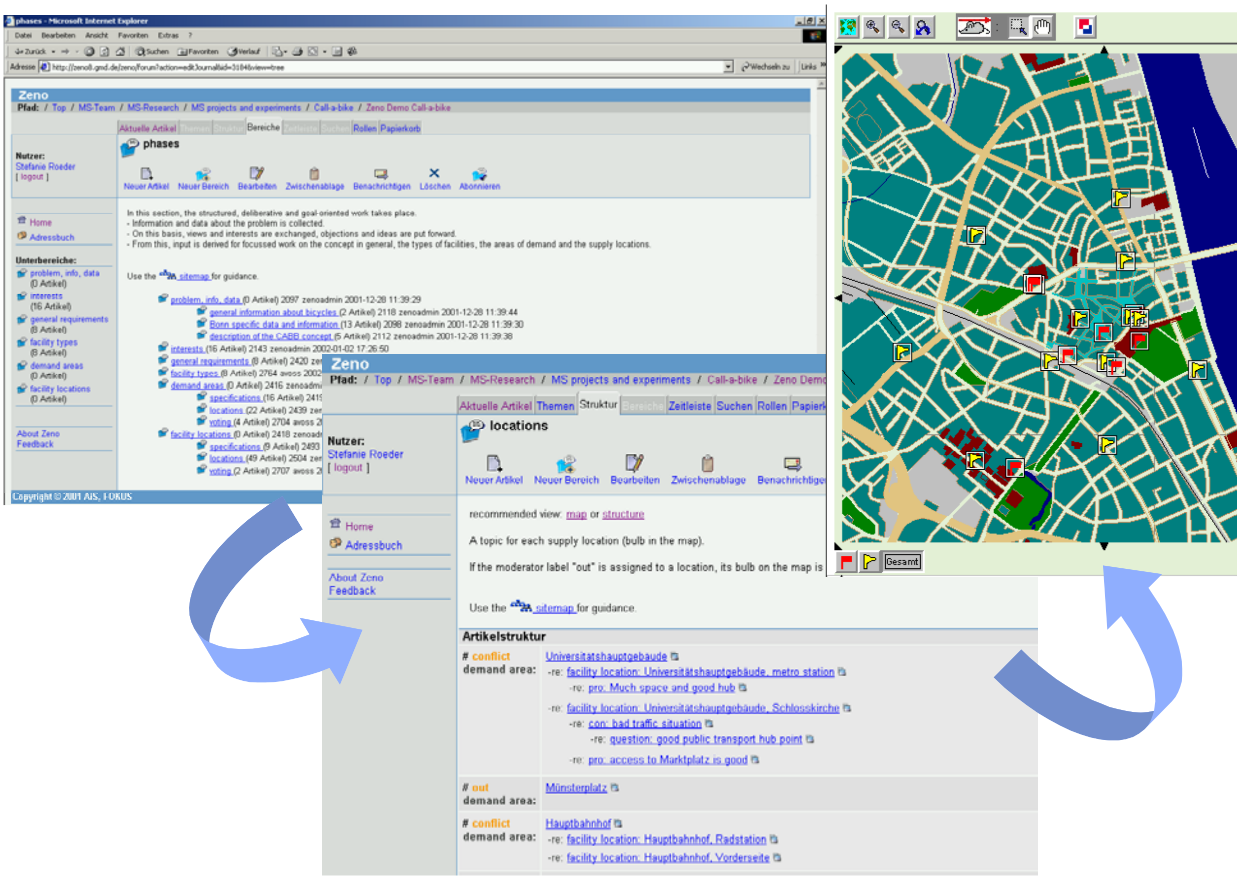


*Figure 2: Call A Bike discourse structure*

## Outcomes and a prospect

Results of the experiments are not only process patterns according to different classes of problem complexity accompanied by operational instructions for conducting the procedure but also general requirements for the supporting software tools and the continuous adaptation of the conceptual development of the integrated software system to the requirements.

A further evolution of models and software is to be expected in the course of experiments. While in the first and second experiment the tools were used stand-alone, in the third experiment there will be a first integrated version. This improves the realization of online phases, especially regarding the convenience of the procedure. While having had mainly asynchronous online support, there will be synchronous online phases in one of the next experiments, which will lead to more parallelism in the discourse structure. The process will get closer to the reality of the "convenience, trust and expertise triangle" [13].

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