**mESA: a Model for Collective Decision Making**

Ana Cristina B Garcia  
ADDLabs/TCC-IC  
UFF – Fluminense Federal University  
Niterói, Brazil  
bicharra@ic.uff.br

Adriana S. Vivacqua  
PPGI/DCC-IM  
UFRJ – Federal University of Rio de Janeiro  
Rio de Janeiro, Brazil  
avivacqua@dcc.ufrj.br

Thiago Cortat Tavares  
IBGE-Brazilian Institute of Statistics Studies  
Rio de Janeiro, Brazil  
thiago.tavares@ibge.gov.br

**ABSTRACT**

Conscious decision making requires deep understanding of (1) the problem, (2) the context framing the problem, (3) the available options, (4) the perceived future resulting from each alternative and, of course, (5) the preferred future. As world becomes more complex and problems more open ended, these pieces of knowledge tend to be spread through several individuals. Finding, collecting, filtering and synthesizing relevant and trustworthy knowledge to understand and solve problems have become big research challenge. In this paper we present the mESA model for collective decision making based on an iterative and interactive process of gathering information and experts, synthesizing knowledge and then questioning hypotheses and expanding discussion. The model was created to support the receipt and processing of a large number of submissions (demands, questions, issues or responses), automatically processing participants’ contributions, clustering knowledge, assisting small groups to interpret clustered information to either produced better informed decisions or guide issues to be further discussed, in a cyclic process. This model was successfully instantiated in mGov, a system for eliciting citizen demands in a participatory government structure. We also discuss how mESA model is a good metaphor to collective problem solving and decision making in participative organizations, that is our next item in our research agenda.

**Author Keywords**  
Collective intelligence, participative decision making, large groups

**ACM Classification Keywords**  
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

**INTRODUCTION**

In recent years, large groups have been widely regarded as a source of valuable information. Defenders of the “wisdom of crowds” claim that the aggregation of individual contributions, under certain conditions, produces results as valuable as that of an expert [9]. Consequently, organizations and governments have turned to large groups as sources to help guide strategic decisions. Researchers have also been studying means to harness information for problem solving and idea generation, through the participation of large numbers of people [6]. These studies and work exemplify a growing trend: academia and organizations alike look for the best ways to harness collective intelligence.

One of the most traditional means of eliciting information from people is through voting: a voting system allows individual to express their opinions given a certain issue and a set of options. Voting is adopted by many countries to elicit citizens’ opinions. However, voting implies choosing from pre-defined options proposed by a small group. Consequently, voting guides but does not enlighten the decision making process. In general, it is unfeasible to listen to the large groups’ demands, desires and ideas, in other to let raise creative solutions and suggestions.

In this paper we present mESA (Multiparty Expansion - Synthesis - Analysis) a three-stage model of participative decision making, where participants not only provide elements for consideration, they also interfere with the synthesis of these elements and with its final outcome. We instantiated this model in a participatory government domain and are now taking the lessons learned from this first experiment and instantiating it in an organizational domain.

In the following sections, we present the mESA model, followed by its instantiation in a government domain. We then briefly present our new project, where the mESA model will be instantiated in an organizational domain. We finish the paper with a brief discussion.

**THE MESA MODEL OF COLLECTIVE DECISION MAKING**

In our research, we have been looking at different ways to harness collective intelligence to solve problems. This goes beyond providing a website where individuals give opinions, to building systems that foster and help manage this feedback and generate coherent solutions to the problem being explored.

We have defined a problem solving process composed of three stages that feed into each other. The mESA (multiparty expansion, synthesis, analysis) problem solving cycle involves three steps (illustrated in Figure 1):
• Expansion: in this phase, new requests, ideas or possible solutions are generated, and the solution space is further explored.

• Synthesis: after expansion, the synthesis phase is where a reduction happens, for instance, through merging of similar ideas. Alternatively, responses to demands or requests may be generated in this phase.

• Analysis: the analysis phase comprises evaluation and selection of the preferred option(s).

This cycle repeats itself, going back to the Expansion phase after an analysis phase, until alternative solutions have been sufficiently explored and refined. The model is generic in that different actors may perform each of the roles. We assume three possible types of actors: the collective (large group of people), the articulator (this may be an individual or a smaller group that coordinates the problem solving process) or a computational agent. Normally, the collective is involved in decision making through voting on alternatives defined by a small group of articulators.

![Figure 1: mESA decision making cycle](image)

This model was applied to a participatory government situation, where individuals were allowed to send in their demand, the government responded with options and the participants could then select the best ones. A system was built to support this process, and is described in the following section.

**MGOV: SUPPORTING PARTICIPATORY GOVERNMENT**

Involving the population in decisions is desirable, because it leads to an increase in confidence in the decision process, the construction of relationships based on trust, transparency and integrity, the identification of multiple interests and needs, and more efficient problem resolution [7]. This need has been noted in several countries, leading to new methods and technologies to enable this collaboration [10].

The idea of using collective intelligence [6] to design new solutions creates new challenges, one of which is making sense of crowds: listening, understanding, interpreting, synthesizing, providing feedback and acting are some issues that must be addressed. Klein [5] proposed an argumentation network in which people share information and discuss over it. This approach only addresses the “collecting knowledge” issue. We are interested in approaching the entire problem of making sense of the crowd. Another approach has been proposed to address group decision making, involving the whole process, from idea generation to final decision, based on the Delphi method [3].

Participatory activities involve the creation of new participation channels between the organizers of the participatory process and the participants, creating forms of interaction between the two, such as referendums, opinion polls, negotiation of regulations, popular juries and focus groups, which in turn increase transparency and social participation [7][4].

Participatory government, in particular budgeting, as adopted in Brazil and many other countries, involves separating a percentage of the budget to demands generated directly by the population [2]. In participatory budgeting, meetings are held periodically at the city, state and country levels, to discuss budget allocation. Any citizen may participate in these decisions, but the entrance barrier is high, as they have to physically attend the meeting and, once there, try to get their ideas across.

Some offices of the government have created websites with voting systems to try to reach a larger part of the population. In 2006, Belo Horizonte, one of the largest Brazilian cities, implemented its PB process in a web-based environment, hoping to increase quality and participation, and named it Digital Participatory Budgeting (DPB.) The same criteria applied to regular PB and to DPB. This was the first successful transition of PB to a digital medium in the country. To succeed, however, the city had to invest heavily in advertisements and in technological infrastructure to ensure that citizens from all social classes had access to computers and the internet and increase popular participation.

In terms of participation, in 2006, Porto Alegre (the city that first adopted participatory budgeting, in 1989) saw a participation of 11.536 citizens, and participation peaked at 17.241 in 2002. Given that the number of registered voters is 1.040.572, we can see that only about 1% of the population participated. Belo Horizonte, after 20 million reais in investments, had 124.320 participants, out of a total of 1.772.227 voters.\(^1\)

However, in these configurations it is up to the government to decide which questions and alternatives should be presented, which reduces the amount of information the citizen may provide. Additionally, a large part of the population does not have easy access to the internet, which greatly reduces their chances to participate. This is particularly true in Brazil, where our study was conducted. However, most of the population now carries cellular phones, making this an ideal platform for government-citizen communication. With the mGov initiative, we

\(^1\) data obtained from official the following regional voting and census offices: TRE-MG, TRE-RS, OPDIGITAL
sought to allow the population at large to send in demands, giving them a direct channel to the government. The mGov system implements the expansion-synthesis-analysis cycle in the governmental domain. In this scenario, the three phases were instantiated in the following way:

- Expansion: emergence of demands, furnished by the population. The underlying system is able to receive, interpret, aggregate and categorize the demands;
- Synthesis: government officials respond to the aggregated demands with possible actions that should answer the demands;
- Analysis: selection of the preferred option(s), by the population at large. In this case, through a voting scheme.

A system was built to implement this cycle, where demands were sent mainly via SMS, but also via WAP and Java mobile application. An experiment was run against a classic website configuration, where the population could access a page to send in demands and vote on alternatives. The mGov system architecture is shown in figure Figure 2 and detailed in the following paragraphs.

**Figure 2: mGov architecture (adapted from [8])**

mGov is composed of the following modules:

- **Interface**: Establishes the interaction with the citizen and the proposed agent. This module is responsible for capturing the user data and demands, and sending them to the identifier. It should be noted that, because it runs in a mobile environment, it becomes necessary, when possible, to have pre-set demands, to simplify citizen interaction. These will usually be limited to generic subjects and needs related to the theme under discussion. In a second stage, the interface receives a communication about the start of the voting period, which enables it to receive votes and send them to deliberation.
- **Identifier**: acts on the identification of demands coming from the interface. Verifies if each demand is a pre-set one and, case it is, sends it immediately to the demand classifier. If it isn’t, the demand is sent to the lexical processor.
- **Lexical Processor**: treats the demand text. Starts by substituting “mobile shorthand” expressions (shortening of words commonly used in the mobile environment) for their equivalent in natural
language. After that, stopwords are removed, as they contain no additional information, and serve only a functional purpose. This leaves us with keywords. We then apply a stemming algorithm to obtain the stem of each keyword, and move on to the next phase.

- **Interpreter:** in this phase, the main task is understanding natural language. To that end, we adopt a domain ontology that refers to the theme of the PB process. With the ontology, ambiguity problems are reduced, and the ontology works as a concept dictionary for the numerous demands sent in. When this module receives the stems that refer to the demands sent in, it generates a set of characteristics, or words obtained through the ontology vocabulary.

- **Demand Classifier:** the demand classifier tries to recognize if a given demand (or a part of it) belongs to one or more previously defined classes. It categorizes and adds up demands according to characteristics obtained in the previous step to one of the existing classes. If there is no correlated category, a new one is created, associated to the closest abstract class and added to the classifier. After that, the demand is stored in the database and a feedback message is sent to the citizen thanking him or her for participating and informing that, as soon as project voting is available, a new message will be sent. After this step, classified demands and user profile information are sent to the profile segmentation module and the prioritized demands (i.e., those most frequently mentioned in this aggregation stage) are sent to the government.

- **Profile Segmentation:** this stage is responsible for processing all the information gathered from crossing the data from the demand classifier with the citizen profile data, and is analyzed with data mining algorithms that may lead to the discovery of patterns and relations that would not be found through simple reading of a large number of demands. Results of this process are sent to the government.

- **Government:** receives the data about prioritized demands, as well as the information obtained through segmentation. The government analyzes this data, elaborating projects or actions that address the main demands raised by citizens. It then directs them to the deliberation.

- **Project Deliberation:** this phase receives all of the projects elaborated by the government and sends them to the citizens so that they can vote on them. It informs the citizens when the voting will start. Once the voting process is started, this module receives the votes and adds them up and, at the end of the process, sends results to the government, who becomes responsible for execution of the selected ones.

- **Vote:** enables the selection between the previously elaborated alternatives.

The mGov architecture was designed to support knowledge acquisition and decision making in collectively designed projects. It combines artificial intelligence methods with decision making techniques to enable a dialogue between decision-makers and participants.

**Experiment and results**

The system was implemented in a university setting, and around 800 participants joined, including students, professors and staff. The theme under discussion was *how to apply university resources to the university restaurant, in order to improve its services.* This was a real issue, under discussion by the dean of the university at the time of the experiment. 200 participants used the cell phone platform and 600 used the web based platform.

The experiment with the cell phone based system lasted about 2 weeks, and we surveyed participants at the end, and around 90% of the total population responded to the questionnaire. About 15% of volunteers who used the web version continued through the end of the process, versus
85% of those using the mobile version. A user profile breakdown can be seen in Table 1.

**Table 1: User profile breakdown**

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>47%</td>
</tr>
<tr>
<td>Female</td>
<td>53%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>&lt; 20 years old</td>
<td>22%</td>
</tr>
<tr>
<td>21 to 30 years old</td>
<td>63%</td>
</tr>
<tr>
<td>31 to 40 years old</td>
<td>9%</td>
</tr>
<tr>
<td>41 to 50 years old</td>
<td>4%</td>
</tr>
<tr>
<td>&gt; 50 years old</td>
<td>2%</td>
</tr>
<tr>
<td>Schooling</td>
<td></td>
</tr>
<tr>
<td>Elementary</td>
<td>4%</td>
</tr>
<tr>
<td>High School</td>
<td>36%</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>52%</td>
</tr>
<tr>
<td>Graduate</td>
<td>8%</td>
</tr>
<tr>
<td>How long using cell phone</td>
<td></td>
</tr>
<tr>
<td>&lt; 6 months</td>
<td>1%</td>
</tr>
<tr>
<td>6-12 months</td>
<td>0%</td>
</tr>
<tr>
<td>1-3 years</td>
<td>5%</td>
</tr>
<tr>
<td>&gt; 3 years</td>
<td>94%</td>
</tr>
<tr>
<td>Using a cell phone is...</td>
<td></td>
</tr>
<tr>
<td>Very complicated</td>
<td>1%</td>
</tr>
<tr>
<td>Complicated</td>
<td>11%</td>
</tr>
<tr>
<td>Easy</td>
<td>53%</td>
</tr>
<tr>
<td>Very easy</td>
<td>35%</td>
</tr>
</tbody>
</table>

As we can see from the profile breakdown, users were young, technologically savvy, and had a fair bit of schooling, which is to be expected given that the experiment was conducted in a university setting. Additionally, when asked whether their cell phones had SMS service, all but one responded it did, and all but 4 responded they regularly used it. A second set of questions determined that 94% of respondents felt that SMS were useful, and 84% had used it more than 10 times in the past 6 months. However, 90% of the group had never participated in any type of SMS based voting activity, such as Big Brother Brazil (the show allows viewers to vote for their favorite participants through SMS). These last question shows that cell phones and SMS technology have experienced widespread adoption throughout cell phone users, which makes it an ideal base for an interactive system.

The experiment was conducted in a two week period, during which participants:

1. sent in the main issues with the university restaurant;
2. received the consolidated results back, and
3. voted on the most important ones.

The first question we asked had to do with user satisfaction: we asked participants whether they felt they were able to express their demands, and an overwhelming majority said they did (96%). The second issue was whether they felt they had been heard by the government. 89% of respondents felt they had been completely heard even when the options presented for voting (on step 2) were not exactly the ones they had submitted. This leads us to believe that the summarization phase worked properly. We also asked participants whether the demands they sent were represented by the alternatives generated by the system and 71% said they were.

An additional observation was that 81% chose to send in their demands via the predefined options instead of writing them in. This leads us to believe that users would rather avoid typing on the cell phone number pad, and therefore they will tend to prefer pre-set options, which might bias the results, and raises the issue of the definition of initial (predefined) options. If an improper set of demands is provided, it may bias participant choice, or lead to incorrect selection. This means initial options must be carefully designed to represent all possible options, or not at all. More research is needed in this front. We will be experimenting with a “no-presets” setting, where there are no predefined options, only free text entry, to see how it affects adoption and what types of demands would be generated. Another possibility would be to use the automatically generated clusters as options, so that the user may see what demands have been sent in and add only if his or hers is effectively a new suggestion. This is however, a limitation of the chosen platform and not of the model itself. It would be interesting to see how users would interact with the system when it is implemented in another medium.

A website was set up to run a comparative test. During 7 days, about 600 people were invited to participate in a decision process that followed exactly the same steps as the one implemented on cell phones. The rate of return was of only 4.4%. In the web version, as in the cell phone case, participants preferred to send in demands using the pre-set options instead of typing them in.

Numbers showed an increase of adoption when using a different medium, as we had expected: 68% of participants stated they would not have participated in a process if they had to go to a physical meeting place. Additionally, about 95% of participants stated they would recommend participation in participatory decisions processes by cell phone to their friends. This indicates that people are willing to participate, but that dislocation to a physical site is too high an entrance barrier. The possibility of participation via cell phone provides a suitable alternative to displacement. Additionally, cell phone also had greater participation than web, which leads us to believe that the preemptive nature of
SMS messages induces responses or action more strongly than email messages, possibly because users already receive a multitude of messages on a daily basis. This is an issue that we feel should be further explored.

Finally, 96% declared they were satisfied with the final result and 86% agreed with the selected demands. Further, 71% felt their suggestions helped improve the university restaurant, another result that leads us to believe that the model works satisfactorily.

The increase in adoption generated an increase in demands sent to decision makers, which, in turn, generated a need for effective methods to cluster and summarize these demands. It is unlikely that decision makers would be able to cope with the large number and diversity of incoming messages without automated assistance. We consider this experiment was a great success and provides a solid first step for future work.

As this approach proved successful in a government situation, we are now exploring its application in an organizational setting. The setting is described in the following section.

**MESAS FOR PARTICIPATIVE ORGANIZATIONS**

Participative management is a type of management where employees have a strong decision making role. Several authors view it in a favorable light, listing a series of potential benefits. Among other things, it increases the connection between employees and the organization; provides participants with a broader point of view, as opposed to their narrower local views; decreased competition between participants and increases participants’ understanding of each other [1]. This makes it a highly desirable configuration, yet, to this day, not many organizations adopt it.

Frequently, organizations must deal with problems that have never been dealt with before. Open ended problem solving may become a big issue if it involves a strategic domain for the organization. Organizations usually put together task forces to solve particular problems, but sometimes the knowledge to solve them may reside with employees that were not involved. Communities of practice [11] are frequently used to elicit participation from different organizational levels, but the information contained in them is usually unstructured and contributions do not follow any problem solving process.

We now have an opportunity to apply the mESA model to a real life problem in an organization. One of our research partners is an oil company, looking for ways to extract oil from very deep waters (more than 2.5 km) and under 2 km of salt (what is known as the pre-salt layer.) This is a new and complex problem, not only for the organization, but for the whole world.

Given the long history of the company and personnel stability, and existence of several communities of practice in the organization, upper management believes that the knowledge of how to exploit these reservoirs and the solutions to problems involved may lie with its employees. Therefore, we are now working with them to apply the mESA model to their problem solving needs. Thus far, we have defined that demands will most likely be provided by the articulation group, and the phases should consist of:

- **Expansion:** emergence of responses and idea generation by employees. The underlying system should be able to receive, interpret, aggregate and categorize these responses/ideas;
- **Synthesis:** employees generate correlations between ideas and concepts, determining which are correlates and how. The system should assist the users in finding the correct correlations and in comparing their representations with others’ models;
- **Analysis:** after the reduction step, the group should select the preferred option(s). This could be done using a voting scheme. The system could also help aggregate the options.

One of the shortcomings we noticed in the previous instantiation of the mESA model was that the Synthesis step was not performed by the collective, but by articulators. Therefore, we are now designing a new system in a way that will allow users to also synthesize contributions. Besides that, we would also like to enable participants to construct a structured representation of the domain and their solutions, as ontology, for example.

One important consideration in this situation is the platform upon which the system will run. As this is a corporate scenario, we will most likely not be using mobile technology, but a desktop-based system. One of the requirements for this system is that it be easily accessible by all individuals involved in the process, which leads us to developing a web-based system, which anyone could access. Additionally, employees are already used to running Lotus Notes applications, so this platform will have to be explored.

As we noticed that the preemptive nature of SMS messages and the ease of sending options induced increased responses from participants, we are studying how to replicate this effect in a different platform. Collective intelligence is highly dependent on the number of participants, and the group decision is the result of the aggregation of their opinions and choices. Thus, communication should be direct and easily handled, with responses being as immediate as possible. One possibility would be to send formatted emails with links leading to responses to the available options. Naturally, the decision step presupposes that participants sent initial suggestions and for problem resolution.

At this point, it should be noted that this is a different scenario from the e-Government one: participants can do
more than define the allocation of resources; they can attempt to design a more complex solution. The company needs to define where investments should be made and what technologies will be important to solve this new problem (pre-salt oil extraction). While some of the technology is known, the organization does not know how to adapt it or where to invest first. Therefore, there is a need to generate alternate possibilities (for instance, devising new equipment based on existing technology), and then test these. This process will probably take longer, but has the potential to generate many returns.

In order to generate viable alternatives (ideas), the group of participants must have sufficient knowledge not only to understand the problem, but also to generate new solutions. This is another point where this situation differs from the previous one: the problem was easily understandable and “solutions” were a prioritization based on individual perception of the most serious problems. This participant selection will most likely be conducted by upper management, who has a fairly good idea of the problem, who wants to retain some level of control over the process. However, we have been talking to them, and believe they might be open to inviting external specialists into the mix, which we believe would greatly benefit them.

Incentive mechanisms might also have to be designed to encourage participation in the process. We are considering mechanisms involving the outcome of the problem solving process, with participants being rewarded for their contributions according to the outcomes (e.g., contributions that were selected as the final solution or that factored in significantly towards the problem resolution might receive more weight than others). This is still an open issue at this point, as we are in the process of producing the initial system design.

This is the next step in our research. We are now defining requirements and mechanisms to implement in the software and introduce into the existing communities of practice. We hope this will prove a viable solution to the organizational problem at hand.

**FINAL REMARKS**

It is frequently the case that an organization has, within its ranks, the knowledge it needs to solve complex problems. What is missing are structured ways to elicit this information. We believe that the mESNAS model provides a bit of structure to the process. We are continuing our work, directing our efforts towards organizational problems.

An interesting observation is that participants in the 21-31 age range had the most positive attitude relating to further participation in cell phone based democratic processes (56% said they would participate in other processes). Similarly, these same individuals believed that cell phones were an effective means of communication with the government. These responses point not only to increased adoption by the younger generation, but to a need for new means of interaction to reach this percentage of the population. This generation was not only born after the internet, it also encountered a world where cell phones are widespread. This usage is redefining the ways in which these people interact and expect to be engaged. Designers need to take that into account when creating new technologies and systems.

Level of instruction was also a significant factor in this experiment. The higher the educational level, the better the system was accepted and the propensity to participate. This was significantly higher among participants with postgraduate education (78%). We assume that this is because a consequence of the level of maturity and general awareness of participants, as the more educated individuals not only have an easier time with the technology, they are usually also better informed about current issues and perceive the importance of participation in governmental issues (this is also a characteristic of many Brazilian university personnel.)

In total, 67% of participants believed that the use of cell phones may serve as a means to send in demands to the government, while a third (33%) disagreed. Naturally, this third wondered if they were actually being heard and what would be done with the demands (would someone look at them?) This shows the importance of the second step, where demands are aggregated and submitted for final voting. This feedback shows that demand were handled and shows the results. This type of feedback should help participants see that their demands are not falling in deaf ears.

Naturally, one of the limitations of our study is that the population was biased, as it involved only university students and personnel. Even though the organizational structure of a (Brazilian) university somewhat resembles that of a small country, the population might not. For one, the educational levels and age distribution wouldn’t have been exactly the same had we chosen another setting. However, we feel this is was already an enlightening experiment, and one that merits being repeated in a wider setting.

We also wonder how well these results would translate to a non-Brazilian scenario. Cultural issues such as levels of political engagement at different ages and preference for SMS messaging and country specific issues such as cell phone adoption and educational levels all might influence the outcomes of such an effort. Additionally, while most of the population now carries a cell phone (even the lower income ranges), these are usually fairly simple, with the basic functionality. In a population with more advanced technology, other means of interaction may be preferable. These issues should be looked into when designing a collective intelligence system: in our case, the system had to reach the widest possible audience, which was why cell phone messaging was selected. In other scenarios, other media may be better.
It should also be noted that the system provided (cell phone based) did not allow for interaction between users. There were no additional facilities for chatting or messaging from within the system, so we do not know if users discussed the demands and the votes outside of the system, and what effect that might have had on the results. On the one hand, anonymity and independence of others’ opinions usually lead to more truthful submissions, but on the other hand, discussion and argumentation frequently lead to new and creative ideas. In decision making, both are desirable, so a balance must be struck between the two.

While we are eager to try out our collective intelligence approach in a new setting, we realize that there are some differences between the two scenarios that require careful thought. First, the group of participants will most likely be selected by management while we had an open participation model in the mGov situation. This generates a problem of participant selection to ensure results are reached. On top of that, upper management will have the final word on which ideas get selected for implementation and how, so the process will be less democratic than the one studied. Second, the set of solutions in the mGov case was rather small and there were few variations, which allowed for the creation of pre-set options. That will probably not happen in this new case, where the problem itself is open ended, allowing for many different solutions, which will be provided by participants themselves. Additionally, these solutions might complement or build upon each other, so participants will need mechanisms for combination and refinement before final selection. Finally, incentives might have to be provided, as helping the organization solve a problem might not be enough to drive participation. Additional incentives might become necessary to ensure contributions.

Some of the problems associated with collective solution generation are provenance (where is the information coming from, and is it reliable?), motivation (what are the incentives to participate?) and coverage (how do you know that the right people are in the group?). These problems may compromise solution generation, and we’ll have to address them as they appear. Regardless, we believe that this approach will lead to valuable solutions, as it has already been proven useful through the mGov experiment.

ACKNOWLEDGMENTS
We thank all students, professors and staff who participated in the mGov experiment. This project was partially funded by Petrobras.

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