Towards an Agent-supported Online Assembly: Prototyping a Collaborative Decision-Making Tool

Antonio Tenorio-Fornés and Samer Hassan

GRASIA group
Universidad Complutense de Madrid
Email: antoniotenorio@ucm.es, samer@fdi.ucm.es

***Abstract*—The promise of online assemblies has been present for years already, and a diversity of tools have attempted to fulfill it. This work aims to reapproach the issue from a novel standpoint that relies on a federated architecture, a real-time collaborative environment, goal-oriented software agents and a consensus-based methodology. Consensuall is a prototype of consensual decision-making collaborative webtool that allows the elaboration, rating and commenting proposals in order to build consensus among a group. The webtool design follows the Agent-Oriented Software Engineering paradigm. Thus, it proposes the use of software agents as complementary automatic participants fulfilling specific roles, as a way to address decision-making common issues. The article presents Consensuall, a prototype of an agent-based collaborative decision-making webtool within the distributed real-time collaborative platform Apache Wave, providing a proof-of-concept of the adopted approach.**

Keywords–Collaborative Decision-making; Apache Wave; Consensus; Agent-Oriented Software Engineering; Multi-Agent System.

I. INTRODUCTION

Post-industrial social movements (also coined "new social movements") emerged since the 1960's in the Western societies [1], and, nowadays, have reached a global impact. These movements are increasingly embracing different forms of consensus decision-making as an organizational principle [2]. This is guided by the belief that this model has the potential to empower participants, acknowledge their great internal diversity, and commit to the ideals of participation, democracy and decentralization [3].

Consensus decision-making covers a broad spectrum of implementations [4], and generally it is not understood as a synonym for unanimity, but as aiming to collaboratively reach an acceptable resolution for all the group members. Consensus-driven group assemblies may have multiple lacks and issues, and multiple methodologies have been proposed to address them, successfully doing so for most of them [5]. Still, it is frequently considered that online tools should boost this model, facilitating both scaling up and speed, while not losing its legitimacy and user participation.

The promise of "online assemblies" has been present for years already, and a diversity of tools have attempted to fulfill it. Besides, the emerging Commons-based peer production online communities do not follow traditional hierarchical organizations, and frequently adopt modified forms of consensus decision-making [6]. Popular examples may be found in free/libre/open source software (FLOSS) [7] or Wikipedia [8]. Still, the forms of achieving consensus through online means still have multiple issues and in some cases are rather rudimentary (such as a mailing lists with "+1" in Apache or a simple Discussion page in Wikipedia).

Multiple online group decision-making tools have been built in order to fulfill this gap (see Section II). This work aims to reapproach the issue from a novel standpoint that relies on a federated architecture, a real-time collaborative environment, software agents and a consensus-based methodology. CONSENSUALL is a prototype of consensual decision-making webtool that allows the elaboration, rating and commenting proposals in order to build consensus among a group. This webtool is developed from an Agent-Oriented Software Engineering (AOSE) approach [9], and proposes the use of software agents as complementary automatic participants. Such agents are inspired by the formal (or informal) roles found in offline assemblies, and aim to facilitate the debate and solve certain flaws of the consensus decision-making process.

This work is structured as follows. Section II introduces different decision-making methods and software tools, with a special focus on consensual decision-making processes and applications. Afterwards, Section III explains the adopted methodology, including the concepts of *software agent* and *AOSE* and the technologies used. The prototype design is presented in Section IV, where the concept of the tool, its functionality and the behavior of the designed agents are introduced. Section V presents the developed prototype, showing the use of the tool through an example, and illustrating the agents' behavior with a sequence of their interactions. Finally, Section VI summarizes the contributions and presents future work.

II. REVIEWING CONSENSUS DECISION-MAKING

This section explores different group decision-making methodologies and software tools that intend to boost participation and agreement in democratic decision-making and compares them with CONSENSUALL proposal.

A. Group Decision-Making Methods

1) Consensual decision-making: In general, a group decision is a consensual decision if all members of the group are willing to commit to a proposal [10]. Consensus building or consensual decision-making is the collaborative process where a group aims to find a consensual decision. This process may be formal [11][12][4] or informal [13].

As discussed in Section I, forms of consensus decision-making are the preferred by different groups, including FLOSS

 ISBN: 978-1-61208-351-3

projects [13][8], social movements [14], groups of unrelated experts [11], or many other communities [15]. These groups tend to see the consensual decision-making process as a method to obtain synergistic output, not achievable by single participants [16] and as an extremely democratic and participatory technique [3].

2) Other group decision-making methods: There are other group decision-making methods that attempt to boost participation and agreement further than traditional majority voting. Some relevant examples follow.

- *Liquid Democracy* also referred as *Delegated Democracy* or *Proxy voting* is a decision-making method that enables both direct democracy and revocable, topic-based, transitive delegation [17]. This method has been adopted by some political parties [18] and other groups and communities [19] and has been implemented in several online applications [17][20].
- *Dotmocracy* is a participatory large group decision-making method. Participants can write ideas in paper "dotmocracy sheets" and rate these ideas with the values {"Strong Agreement", "Agreement", "Neutral", "Disagreement", "Strong Disagreement", "Confusion"}, together with some qualitative comments [12].
- *Dynamically Distributed Democracy* is a method to approximate a group opinion when not all members of the group participate. It uses a social network of the transitive relations of trust within the group to calculate the opinion of non participants by the opinion of their trusted participants [21].

B. Group Decision-Making Software Applications

There are different online group decision-making tools. These software tools differ in the target groups and group sizes, the methods they implement (see Section II-A), the collaboration degree, the required level of agreement, or might have a wider or more concrete scope of application. These and other dimensions are considered in the comparison among some of the most important decision-making tools or resources and the CONSENSUALL proposal.

1) E-voting & Polls: There are plenty of software tools implementing majority voting and polls. These tools are used by different kinds of groups for democratic decision-making. Generally, e-voting and polls do not allow a high degree of collaboration, they usually lack discussion support and proposal modification/addition. Among these tools there are voting platforms [22][23] and poll extensions integrated in software platforms such as forums, social networks (e.g., Facebook) or collaborative environments (e.g., Apache Wave). There are also domain-specific voting tools, such as "Date matchers" (e.g., Doodle [24]), software systems to collectively decide appointment dates.

2) Adhocracy: is a participatory platform for democratic decision-making. It targets communities, organizations and citizens [20]. Users can make proposals, add an alternative proposal to an established proposal, comment proposals, and vote proposals with either +1 or -1 vote. The tool implements liquid democracy (see Section II-A), allowing users to delegate their votes for specific topics to a trusted user.

3) LiquidFeedback: is a liquid democracy (see Section II-A) decision-making tool for communities and citizens [17][19]. As in Adhocracy, a user can propose, make an alternative proposal, rate, and comment. It uses preferential voting (i.e., Schulze method [25]) to boost collaboration and avoid rival competitive voting.

4) Delphi: is a formal consensual decision-making method consisting of an iterative process of elaboration and response of questionnaires [11]. This method is commonly used to obtain expert opinions and forecasting, although it can be applied for other purposes [11].

5) Loomio: is an online consensus decision-making tool for communities [15]. It allows users to create topics, to propose and rate proposals with the values {"Agree", "Abstention", "Disagree", "Block"}; comments are allowed during the topic main discussion, the proposal discussion and the rating of proposals, which enhance collaboration to achieve consensus.

Lommio is the most similar to this paper's proposal. However, there are several differences: CONSENSUALL uses software agents interacting within the tool as a way of improving consensus decision-making process. It takes advantage of a real-time environment, together with a federated architecture (see Section III-B); besides, CONSENSUALL enables the parallel discussion and rating of more than one proposal while Loomio only allows the rating and discussion of a proposal at a time, which mimics offline assemblies behavior.

Other general purpose tools are also used for decision-making (e.g., mindmapping, videoconference, collaborative writing). However, those fall out of the scope of this paper.

C. Multi-Agent Systems for decision-making

MAS have been applied to assist decision-making. In decision support systems, some MAS provide information aiding to choose a decision [26]. In the negotiation process, MAS may help to obtain favorable deals [27]. However, these systems focus on decision-making scenarios such as business negotiations and domain-specific decisions. Moreover, within these negotiation systems (as in market environments) parties are usually considered competitive, rational and self-interested (i.e., following Rational Choice Theory (RCT) [28]). CONSENSUALL is a general-purpose decision-making tool, and designed for a collaborative context with group aims and emotional links among members, far from a RCT approach.

III. METHODOLOGICAL APPROACH

This section introduces the methodological approach of the proposal. Explaining its AOSE perspective and technologies.

A. Agent-Oriented Perspective

The software has been designed and developed with an AOSE perspective [9].

Software Agents are software systems that possess: *autonomy*, *social ability*, *reactivity* and *pro-activeness* [29].

 ISBN: 978-1-61208-351-3

AOSE is devoted to the development of Multi-Agent Systems (MAS). AOSE uses software agents and their interaction as the basis for the specification of its systems. It is frequent in AOSE works to follow a Model-Driven Engineering (MDE) methodology [30], which implies the use of intermediate languages between the conceptualization and the implementation of models, facilitating the model description and replicability.

The introduction of agents in order to extend the decision-making tool is one of the main contributions of CONSENSUALL. In offline consensual decision-making, many issues are addressed by specific participants that play a formal (or informal) role, through interventions in the assembly [4]. This inspires the conception of automatic participants (agents) addressing specific roles within the system.

On top of the use of agents, the use of Agent-Oriented design has been a useful tool to conceive the prototype. Objects as agents (also used as Actors in the prototype design), roles, goals and actions, have been helpful abstractions for the design purposes.

B. Technologies

The INGENIAS [31] methodology, a software development methodology for MAS, have been used for the design of the tool. It adopts a MDE approach with two basic components: a modeling language and software tools. A metamodel specifies the INGENIAS modeling language. It defines the available concepts and relationships, together with their properties and constraints. Within this framework, an agent is mainly characterized in terms of its goals and the capabilities it has to accomplish them. Besides, agents participate in interactions with other agents to achieve global goals.

Thus, CONSENSUALL follows an Agent-Oriented perspective, using the metamodels provided by the INGENIAS tool, i.e., an intermediate graphical language to design the tool.

The webtool CONSENSUALL has been conceived as an *app* running on top of a FLOSS federated real-time collaborative platform, being Apache Wave [32] or Kune [33]. Wave is a technology that was initially developed by Google (and known as Google Wave [34]), and later transferred to the Apache Foundation and released as FLOSS. The Wave Federation Protocol [35] is the first protocol for full federation of contents in multiple servers with real-time transparent synchronization among them. Kune is a Wave-based federated collaborative platform which integrates social-networking features, and is under the umbrella of the Comunes Nonprofit [36].

The Wave technology allows the development of *Gadgets* or applications embedded into conversations [37] and *Robots* or automatic participants [38] that can perceive changes in gadgets and conversations and participate in them. CONSENSUALL takes full benefits of the potentials of this technology: the decision-making space where users and agents interact by building, rating and commenting proposals is implemented as a Gadget. Finally, agents are implemented as Wave Robots.

Gadgets and Robots have been developed using Java and the Google Web Toolkit (GWT) [39], which allows the automatic generation of JavaScript code from Java code.

IV. THE WEBTOOL DESIGN

The proposed prototype has been designed using the AOSE methodology INGENIAS [31]. This section explains such design using the INGENIAS "Agents", "Interactions" and "Goals and Tasks" viewpoints, illustrated with INGENIAS metamodel diagrams in Figures 1, 2 and 3.

A. Concept

CONSENSUALL is a prototype of a collaborative consensus decision-making tool. It is inspired in offline consensual assemblies but takes advantage of online real-time collaboration provided by its technology (see Section III-B). The decision-making webtool, developed as a Wave Gadget [37], can be introduced in any part of a wave document or wave conversation and is conceived as a generic tool for any Wave [32]/Kune [33] community.

The proposal introduces software agents (see Section III-A) as a way of extending the decision-making webtool. These agents, automatic participants in wave conversations [38], interact with the user and the webtool as other participants: posting comments, adding or rating proposals. This feature is inspired by the roles and interactions in offline assemblies to solve some of the most common issues in the consensus seeking process. Two agents have been developed to prove the appropriateness of this approach: a "consensus seeker" agent and a "participation seeker" agent; the definition of these agents (Section IV-E) and an example of their interaction with the users and the tool (Section V-A) are detailed below.

B. User and Agent Participants

The introduction of software agents as an extension of the decision-making webtool is one of CONSENSUALL's main contributions. This inclusion of agents in the tool provides a modular solution to address a variety of issues in decision-making processes (see Section VI-B for other interesting new agents). Thus, each group may invite the agents they find useful and could develop new agents to solve their problems without modifying the decision-making tool.

Both software agents and users have been considered to play the *role* of Participants of the tool (see Figure 1). These participants are able to perform different *actions*, described below.

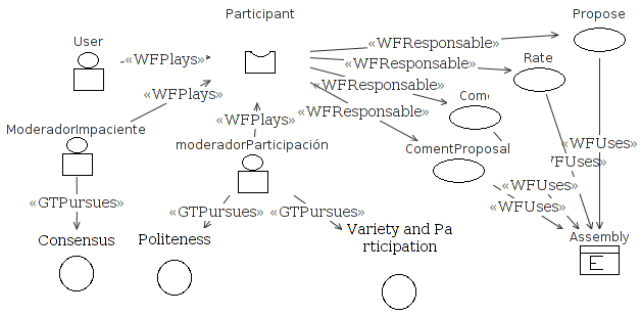

Figure 1. INGENIAS diagram of the Agent viewpoint in Consensuall

C. Actions

Consensus decision-making is a process that involves deliberation, to make proposals, rate these proposals and reformulate or make new proposals [10]. In CONSENSUALL, each participant, (either user or agent) can post a general comment, make a proposal, comment proposals and rate proposals. These interactions are depicted as the *actions* "Comment", "CommentProposal", "Rate", "Propose" in Figure 1. These actions facilitate the deliberation (performed through messages and comments in the real-time collaborative environment) and allow the easy creation and rating of proposals.

The diagram in Figure 2 shows the design of the interaction triggered by one of these actions ("Proposal") in an INGENIAS "Interaction" viewpoint. That figure shows that a proposal interaction contains an initiator participant and many participants that collaborates in the interaction, meaning that a specific participant (either user or agent) makes a proposal and the others receive it and interact within this conversation ("ProposalConv").

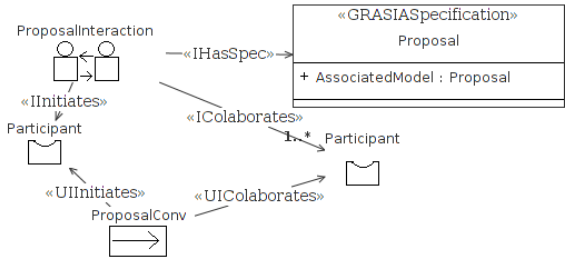

Figure 2. INGENIAS diagram of the "Interaction" viewpoint within a Proposal interaction.

The mentioned action *Rate* deserves special attention, and thus it is discussed in the following subsection.

D. Proposal rating

The possible ratings users can give to proposals have been chosen to facilitate consensus building. Similar to the options provided in Loomio [15] or dotmocracy [12], CONSENSUALL provides 5 rating options: *"Agree"*, *"Do not care"*, *"Do not agree"*, *"Block"* and *"Not decided yet"*. This set of options allows users to express their opinion about an specific proposal better than with a binary rating used by other tools. Among the rating options, distinguishing the block or veto [4] (different than "Do not agree") is a desirable feature in consensus building, since without it, a user cannot express that consensus has not been obtained yet. That is, a proposal is considered blocked just if one or more participants select the "Block" rating. A proposal with no Blocks is considered a valid resolution even if it contains "Do not agree" ratings, as by default consensus does not require unanimity. It should be noted that, as consensus is a collaborative process where opinions change, the ratings can be modified at any moment.

E. Proposed Agents

Two agent prototypes have been implemented to illustrate the interest of this resource in decision-making tools. One of the agents pursues the achievement of consensus while the other aims to encourage participation and good manners (Figure 1). The development of other interesting agents is discussed as future work (Section VI-B).

1) Consensus seeker: The "consensus seeker" agent (*ModeradorImpaciente* in Figure 1) aims to obtain consensus. To improve the odds of obtaining its goal, this agent writes a generic comment to participants *blocking* a proposal (see Section IV-D), in the case that such participant is the only one blocking the proposal. The design of this behavior can be observed in Figure 3.

2) Participation seeker: The "participation seeker" agent (*ModeradorParticipacion* in Figure 1) aims to boost participation in the decision-making process and to keep a polite discussion. In order to increase participation, it makes generic comments encouraging users that have not participated yet to vote and comment. In order to keep a polite discussion, it blocks proposals which have either rude words or orthographic mistakes, explaining in a proposal comment its reasons for blocking. When the "participation seeker" agent is asked to unblock a proposal by the "consensus seeker" agent, the former may tolerate orthographic mistakes (and thus it will unblock if requested) but will not tolerate rude words (and thus it will remain blocking until they are removed). See Figure 3 for a design diagram representing this behavior.

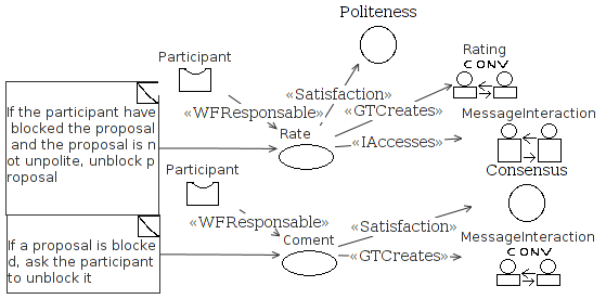

Figure 3. Part of the INGENIAS diagram of the "Goals/Tasks" viewpoint.

F. Agents and Webtool integration

Both Wave Robots (agents) and Wave Gadgets (decision-making webtool) are aware and react to changes in Gadgets state. Considering this, the integration among the agents and the decision-making tool is done through a shared data model of the state of the consensus decision-making process. Being aware of the data model and being able to perceive and create changes in the state, robots can, for instance, interpret a new proposal when it is inserted, or insert a proposal by themselves. Similarly, the webtool can also perceive when an agent performs an action and it may refresh its displayed information.

V. THE PROTOTYPE AT WORK

The presented design (see Section IV) has been implemented in an available working prototype [40]. This section presents the prototype, showing an example where the users and agents (Section III-A) interactions are explained.

A. Example of use

This section explores the users and agents interactions with the decision-making tool.

1) Starting: To start a decision-making process using CONSENSUALL, the prototype has to be included in a wave document/conversation as a gadget. In order to do so, its URL [40] has to be inserted in the Gadget Selector pop-up of any wave document/conversation. Participants of the wave can then invite agents as if she was inviting any other user (these agents must be previously registered with their own username in any Wave server).

2) Proposing: To insert a proposal, participants should provide a title of the proposal and a description. Once a proposal is done, participant can rate it as discussed below. The proposal insertion dialog is located in the upper part of the GUI (see Figure 4).

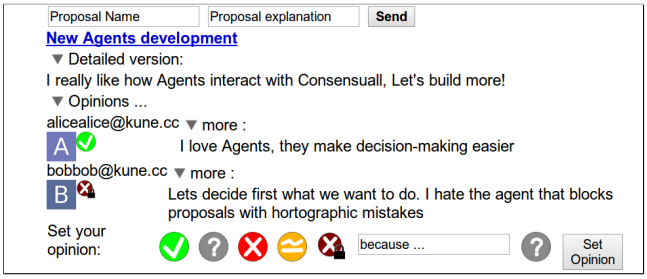

Figure 4. CONSENSUALL User Interface of a new proposal

3) Rating and commenting a proposal: Participants can rate and comment a proposal. Participants should select their rating to the proposal and may insert an optional comment. Figures 6 and 7 show ratings and opinions by one of the agents.

4) General comments: Comments can be added in the wave conversation as it is usual in waves. Figure 5 shows a comment done by "Consensus seeker" agent reacting to previous user interactions in Figure 4.

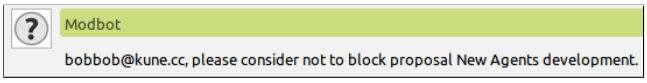

Figure 5. "Consensus seeker" agent asking a user not to block a proposal.

B. Agents interaction

This section presents an example of a non-trivial agent interaction and is illustrated by image captures of the prototype. A description of the behavior of the developed agents can be found in Section IV-E. Both "consensus seeker" and "participation seeker" agents are used in this interaction example.

The interaction starts when a participant makes a proposal with orthographic mistakes. This triggers the following sequence of agent interactions:

1) "Participation seeker" agent, in order to achieve the goal "politeness"(see Figure 1), blocks the proposal, writing a comment in the proposal requesting to rewrite it.
2) "Consensus seeker" writes a comment (analogous to comment of Figure 5) asking "participation seeker" not to block the proposal (as it is the only participant blocking it).
3) "Participation seeker" agent unblocks the proposal after "consensus seeker" agent's message and changes its comment to the proposal (see Figure 7).

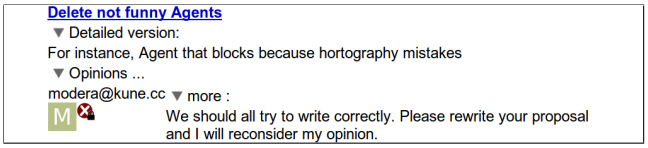

Figure 6. "Participation seeker" agent blocking a proposal.

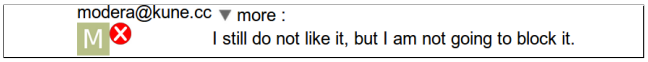

Figure 7. "Participation seeker" agent rating a proposal.

Direct communication among agents, such as the shown message asking other agent to unblock the proposal, could be enhanced by the definition of an *agent communication language* for the proposal domain. This feature is considered as future work (Section VI-A).

VI. CONCLUDING REMARKS

A. Conclusion

The article presented CONSENSUALL, a prototype of a collaborative consensual decision-making webtool. CONSENSUALL provides a decision-making environment where users can elaborate, rate and comment proposals. Additionally, the application allows the introduction of software agents as automatic participants to address common consensus decision-making issues, inspired by the roles adopted in offline assemblies.

The webtool has been designed with an AOSE [9] perspective and software tools (INGENIAS). The use of such tools and methodology have facilitated the development, providing useful concepts and abstractions for the design and conception of the application.

The technology used fits the needs of CONSENSUALL approach. Apache Wave [32] provides a real-time collaborative environment that favors collaboration, needed in a deliberative decision-making process. Wave Gadgets [37] facilitate the development of webtools that may be inserted in wave conversations and shared among participants, and thus it is suitable to build the decision-making prototype. Wave Robots [38] allow the development of software agents as participants, as the article shows with two examples. Their easy development and insertion in the environment makes them a valuable option for a modular improvement of the application.

The results state the feasibility of the proposal, constituting a proof of concept for the future development and research identified in the next subsection.

B. Future Work

The most obvious future research lines point towards scaling consensual decision-making [8][41] and exploring the implementation of different forms of consensus [4] or even other decision-making methods (see Section II-A).

 ISBN: 978-1-61208-351-3

As proposed above, the tool may be extended by the development of new agents, that can be identified in collaboration with users and communities. Examples of some other agents may be: elaborated versions of the two proposed agents; an "egalitarian participation moderator" that points out unbalances in participation (i.e., low participation of female participants or minorities) and encourage the group to solve this issue. The development of an *Agent Communication Language* (for instance, compliant with the FIPA ACL standard [42]), as proposed in Section V-B, would allow interesting interactions among agents.

Some additional improvements, such as its GUI or wave integration or the use of visualization tools, may transform this prototype in a usable webtool for standard users, allowing to make experimentation in real communities. Thus, this would allow further exploration of the potentials of the CONSENSUALL consensus decision-making webtool and its associated software agents, allowing to asset the adequacy of the tool and agents to improve the desired characteristics of consensus decision-making such as democracy, diversity, quality of the decision or required time.

ACKNOWLEDGMENTS

This work was partially supported by the Framework programme FP7-ICT-2013-10 of the European Commission through project P2Pvalue (grant no.: 610961).

REFERENCES

[1] S. M. Buechler, "New social movement theories," The Sociological Quarterly, vol. 36, no. 3, 1995, pp. 441–464.

[2] D. Della Porta, "Consensus in movements," Democracy in social movements, 2009, pp. 73–99.

[3] P. G. Coy, Consensus Decision Making, Northern Ireland and Indigenous Movements. Elsevier, 2003, vol. 24.

[4] C. L. Butler and A. Rothstein, On conflict and consensus, 3rd ed. Food Not Bombs, 2007.

[5] A. Mindell, Sitting in the fire: Large group transformation using conflict and diversity. Lao Tse Press Portland, OR, 1995.

[6] Y. Benkler, The wealth of networks: How social production transforms markets and freedom. Yale University Press, 2006.

[7] S. O'Mahony and F. Ferraro, "The emergence of governance in an open source community," Academy of Management Journal, vol. 50, no. 5, 2007, pp. 1079–1106.

[8] A. Forte and A. Bruckman, "Scaling consensus: Increasing decentralization in wikipedia governance," in in Proc. of the 41st Hawaii Int. Conf. on System Sciences, 2008, pp. 157–157.

[9] B. Henderson-Sellers and P. Giorgini, Agent-oriented methodologies. IGI Global, 2005.

[10] R. O. Briggs, G. L. Kolfschoten, and G.-J. de Vreede, "Toward a theoretical model of consensus building." in Proceedings of AMCIS, 2005, p. 12.

[11] H. A. Linstone and M. Turoff, "Delphi method: techniques and applications." Addison-Wesley, 1975.

[12] J. Diceman, "Dotmocracy," http://dotmocracy.org/, acc.: 2014-05-05.

[13] R. Zilouchian Moghaddam, "The structure of consensus building in online design discussions," University of Illinois, Tech. Rep., 2011.

[14] M. Maeckelbergh, "Learning from conflict: Innovative approaches to democratic decision making in the alterglobalization movement," Transforming Anthropology, vol. 21, no. 1, 2013, pp. 27–40.

[15] Loomio Co-operative Limited, "Loomio," http://www.loomio.org, acc.: 2014-04-24.

[16] L. K. Michaelsen, W. E. Watson, and R. H. Black, "A realistic test of individual versus group consensus decision making." Journal of Applied Psychology, vol. 74, no. 5, 1989, p. 834.

[17] J. Behrens, A. Kistner, A. Nitsche, and B. Swierczek, The Principles of LiquidFeedback. Berlin: Interaktive Demokratie e. V., 2014.

[18] A. Litvinenko, "Social media and perspectives of liquid democracy: the example of political communication in the pirate party in germany," in Proc. 12th European Conference on e-Government, Barcelona, 2012, pp. 14–15.

[19] F. De Cindio and S. Stortone, "Experimenting liquidfeedback for online deliberation in civic contexts," in Electronic Participation. Springer, 2013, pp. 147–158.

[20] Liquid Democracy e.V., "Adhocracy," http://adhocracy.de/, acc.: 2014-04-24.

[21] M. Rodriguez et al., "Smartocracy: Social networks for collective decision making," in System Sciences, 2007. HICSS 2007. 40th Annual Hawaii International Conference, 2007, pp. 90–90.

[22] 15-M Movement and aLabs, "Propongo," http://propongo.tomalaplaza.net/, acc.: 2014-05-04.

[23] J. González González, "Virtualpol," http://www.virtualpol.com, acc.: 2014-05-05.

[24] Doodle Team, "Doodle," http://doodle.com/, acc.: 2014-05-10.

[25] M. Schulze, "A new monotonic, clone-independent, reversal symmetric, and condorcet-consistent single-winner election method," Social Choice and Welfare, vol. 36, no. 2, 2011, pp. 267–303.

[26] J. Jordán, S. Heras, S. Valero, and V. Julián, "An argumentation framework for supporting agreements in agent societies applied to customer support," in Hybrid Artificial Intelligent Systems. Springer, 2011, pp. 396–403.

[27] G. E. Kersten and G. Lo, "Negotiation support systems and software agents in e-business negotiations," in The first international conference on electronic business, Hong Kong, 2001, pp. 19–21.

[28] VV.AA., Rational choice theory, J. S. Coleman and T. J. Fararo, Eds. Sage Publ., 1993.

[29] M. Wooldridge and N. R. Jennings, "Intelligent agents: Theory and practice," Knowledge Engineering Review, vol. 10, 1995, pp. 115–152.

[30] R. France and B. Rumpe, "Model-driven development of complex software: A research roadmap," in Future of Software Engineering. IEEE Computer Society, 2007, pp. 37–54.

[31] J. Pavón, J. J. Gómez-Sanz, and R. Fuentes, "The ingenias methodology and tools," Agent-oriented methodologies, vol. 9, 2005, pp. 236–276.

[32] A. S. Foundation, "Apache wave," http://incubator.apache.org/wave/, acc.: 2014-05-05.

[33] C. nonprofit, "Kune," http://kune.ourproject.org, acc.: 2014-05-05.

[34] G. Trapani and A. Pash, The complete guide to Google Wave. 3ones Inc, 2010.

[35] A. Baxter et al. Google wave federation protocol over xmpp. https://wave-protocol.googlecode.com/hg/spec/federation/wavespec.html. Acc.: 2014-05-05. (2009)

[36] "Comunes nonprofit," http://comunes.org, acc.: 2014-05-05.

[37] Google, "Google Wave Gadgets API," http://www.waveprotocol.org/wave-apis/google-wave-gadgets-api, acc.: 2014-05-06.

[38] ——, "Google Wave Robot API," http://www.waveprotocol.org/wave-apis/google-wave-robots-api-overview, acc,: 2014-05-06.

[39] B. W. Perry, Google web toolkit for ajax. O'Reilly Media, Inc., 2007.

[40] Consensuall development team, "Consensuall Gadget," http://consensuall.ourproject.org/consensuallGadgetDeploy/org.ourproject.consensuall.gadgetdeploy.client.ConsensuallGadget.gadget.xml, acc.: 2014-04-24.

[41] M. Rodriguez and D. Steinbock, "A social network for societal-scale decision-making systems," North American Association for Computational Social and Organizational Science Conference Proceedings 2004, 2004.

[42] P. O'Brien and R. Nicol, "Fipa — towards a standard for software agents," BT Technology Journal, vol. 16, no. 3, 1998, pp. 51–59.

 ISBN: 978-1-61208-351-3