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| **A. Overview** | **A.1. Purpose** | Garbage Can agent-based model is designed and developed to study process of collective decision-making.<br><br>The concept of GCM is decision making, which resolve Problems. Problems have Energy Required (ER) for their decision, Managers (decision makers) have Effective Energy (EE) for the decisions generation. The place of decision-making is the Choice Opportunities (Choices) - abstraction of committees, consul boards and so on.<br><br>The size of the model is determined by the number N (variable **model_size**). In the model there are N choices and managers and 2N problems. The modeling process takes 2N points in time.<br><br>The Choices and Problems open randomly. The Problems activated by two items and Choices by one item per step of modeling (tick) in first half of modelling time. All Managers are ready for action from first modelling step. Problems and Managers access to Choices in according with system structure. There is three types of Problems access to Choices and three types of Managers access to Choices.<br><br>Unsegmented access type is full access for all Problems (Managers) to all Choices.<br>Hierarchical access type is access for first and second Problems (first Manager) to Choice number one, access for third and fourth Problems (second Manager) to Choices number one and number two and so on.<br>Specialized access type is access for first and second Problems (first Manager) only to Choice number one, access third and fourth Problems (second Manager) only to Choices number two and so on.<br>The structure of the decision-making system determines the result of its work in the most essential way. The number of solved problems and the types of solutions worked out depends on it. See further Details section. |
| | **A.2. Entities, state variables and scales** | |
| | *Agents/individuals* | Agents in the model are choices, problems and managers. |
| | *Spatial units* | Spatial units in the model are absent, in the sense that space (word) is used for visualizing the relations of objects. Localization of managers and problems in choices at each point in time is shown on the model's space with the help of symbols (faces, circles, persons and inscriptions, denoting types of solutions developed). |
| | *Environment* | In the model there are no affecting (external) forces that drive the behavior and dynamics of all agents. |
| | *Collectives* | Collectives in the model are the groups of managers united at a specific point in time in one choice. The principle of fluid participants determines the variable composition of such teams. The aim of the teams is to solve the problems present in this choice by combining (with the accumulation) of effective energy managers. |

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| | A.3. Process overview and scheduling | One time step represents one moment decision-making process.<br>On each step of modelling Problems and Managers checks the accusable (in according with system structure) Choices for minimal level of (ER - EE), i.e. Choice nearest to decision, and migrate to it. Then, all opened Choices checks decision rule.<br>If ER <= EE decision with type "Resolution" carried out, the Choice and attached to it Problems closed. If no one Problem attached to open Choice at the step of modelling, Choice will be closed. There is decision "Oversight" (no problems for the committee).<br>If it was Problems in the Choice in past, but now Problems leave the Choice (migrates to other Choices), Choice closes. There is decision "Flight". EE of Managers, accumulated in the Choice, wasted.<br>The main difference between Problems and Managers is: Problems transfers their ER from Choice to Choice in the process of migration, but Managers get their EE by quantums and leave EE in Choices in the process of migration.<br>Model simulation of the decision-making system was carried out as follows:<br>1. model time is discrete and is a sequence of 20 periods (steps of calculation);<br>2. is generated a flow of choices, i.e. random sequence of numbers from 1 to 10;<br>3. is generated a flow problems, i.e. random sequence of pairs of numbers from 1 to 20 (in every moment of discrete time model are two problems), i.e. all problems will be generated in the first ten points of modeling time;<br>4. at each time point all the managers and all activated problems selected according to the decision and access structures opportunity choice closest to the solution. Such a possibility is to choose the lowest energy difference between the ER and EE. |
| **B. Design concept** | B.1 Theoretical and Empirical background<br>*Basic principles.* | This model is based on the paper<br>Cohen, M., March, J. & Olsen, J., 1972. A Garbage Can Model of Organizational Choice. Administrative Science Quarterly, Volume 17, pp. 1-25<br>and author's reconstruction of the logic of the decision-making system, given in the works:<br>1. Smarzhevskiy, I., 2014. Garbage Can Model: Reconstruction and Logical Analysis : http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2490388<br>2. Smarzhevskiy, I., 2014 Four Border Structures in GCM (Small Addition to the 'Garbage Can Model: Reconstruction and Logical Analysis'): http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2519433<br><br>The model developed by M. Cohen and J.March and J. Olsen ( (Cohen, et al., 1972)), is a simulation and describes the adoption of the set of decisions in an organization on the basis of event streams: the problems and choice opportunities. |

Applicability range of the garbage can model is very broad, since the declared characteristics of the organization that is the subject of modeling, do not represent a severe limitation. In particular, the fluid participation means creating and disbanding in the organization of committees and commissions, at the meetings of that address, as is the practice of management. In addition, to paraphrase a classic, we can say that the organization remains, as people come and go, that is, purpose of decision-makers, changing with the phases of their career cycles, and by the very fact of membership. Specialization problems in the model is not specified, the flow problem is simply a set of numbers.

Algorithmic part of the model does not specify such a limitation, as the complexity of the technology. Flow problems comes in decision-making, in the content of the model is not present, and the only thing that can be understood in such a representation problems facing the organization, it is not the hassle, going beyond their operating activities. Consequently, this policy issues. But for many organizations, having the (declared) clear objectives, a characteristic way to react to changes in the environment is the strategic issues by forming a temporary organizational structures: committees, commissions etc..

A key element of the model is the choice opportunity, abstracting any organizational form of the interaction of decision makers. To solve the problems, a certain level of energy. The required energy problem abstracts a level of complexity, effective energy - competence of the manager and his energy in the truest sense of the word.

Access structure determines the availability of choices for problems: hierarchical, specialized or unsegmented. Access problems to the choices given by a matrix of the form (an example of the structure of small dimension)

1 1 1
1 1 1
1 1 1
1 1 1
1 1 1
1 1 1

where the columns correspond to the range of choice opportunities and lines - problems. This matrix defines a unsegmented structure in which any choice is available for any problem. The hierarchical structure is the matrix of the form

1 0 0
1 0 0
1 1 0
1 1 0
1 1 1
1 1 1

which means that the availability of the first choice (first column), for all problems, and the second choice - to problems with numbers 3 to 6 and a third choice - for the 5th and 6th problems. In the original work of problems is twice

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| | | the number of choices, i.e . one possibility to have access select at least two problems.<br>Specialized access means access for one problem only one choice and is given by the matrix of the form<br>1 0 0<br>1 0 0<br>0 1 0<br>0 1 0<br>0 0 1<br>0 0 1<br>In this case, the first choice is available for the problems with the numbers 1 and 2, the second - for the 3rd and 4th problems and so on.<br>Availability of choices for decision makers is determined by the type of organizational structure (decision structure): hierarchical, specialized or unsegmented. Matrix of the form<br>1 1 1<br>1 1 1<br>1 1 1<br>where the rows correspond to the range of choice opportunities and the columns - managers, defines a unsegmented access managers to the choice opportunities - each manager each manager is available any choice opportunity.<br>Hierarchical access given by a matrix of the form<br>1 1 1<br>0 1 1<br>0 0 1<br>that, in this example, is the availability of the first choice (top row) for all managers, the second choice - for the second and third of managers, and third choice for only the third manager.<br>Specialized decision structure is the matrix of the form<br>1 0 0<br>0 1 0<br>0 0 1<br>In this case, each manager is available for only one choice.<br>A choice opportunity is the key structural element (garbage can) forming a model that links the problem with managers. That choice is a garbage can, which lists the elements of flow problems that can connect to both problems and managers.<br>Another important concept of the model is the effective energy (effective energy, EE), which has the organization as a whole, and in some way distributed among managers. Distribution is constant in time and has three options: equal distribution, the distribution of "important people - more energy," and the distribution of "important persons - less energy." Important are those who have access, according to a given structure of the matrix, for more choices. Distribution of "important people - more energy" is as follows: 1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 units of energy. With a uniform distribution of each manager has 0.5 units of the effective energy at each step of the process to be simulated enterprise solutions.<br>The idea of the model is that the problems require energy for their decision, and managers are a source of energy. Problems carry the energy load specified by the variable Load. In the original paper considered three options to boot the system |

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| | | decision-making, in which the variable Load mattered 1.1 2.2 3.3 respectively. To solve this problem requires energy in the amount specified variable Load. The idea of the model is that the problems require energy for their solutions (energy requirement, ER), and the managers are a source of energy. Net Energy Load value is the difference between the total energy managers (66 units) and the total energy required to resolve all twenty problems are gradually coming into the system.<br>For three values of the variable Load, above, the values of Net Energy Load $ 66 - 22 = 44, 66 - 44 = 22 and 66 - 66 = 0 In the third case, the total energy managers enough to solve all the problems in the first two cases, there is some stock.<br>However, the structure of the access problems to managers and key elements of the model - a choice - complicates the decision-making, even in the case of positive values of Net Energy Load with the result that not all the problems that come in the decision-making system are resolved.<br>The dynamic elements that undergo a change of choices states: inactive - active - closed (resolved). Solutions are output model and the model produced at certain points of the discrete model of time. Part of the problem and choices, with a heavy load can remain active at the end of the process model. Thus, the decisions will be made not for all the choices and problems (all or part) remain unresolved. Managers, being quantitatively constant, represent the flow in terms of their migration - they can move from one choice to another. The fluid participation, stipulated as one of the hallmarks of organized anarchy, inherent in a simulated organization is manifested in the dynamics of relations managers with a choice.<br>Decision in the literal sense of the word in the model is the "closing" active choice in which all attached to it (at the time of the decision) problems are also "resolved."<br>There are three types of solutions.<br>If the problem at this time of simulation in this choice does not appear, choice just closes. This type of solution is called «Flight», the solution of this type occurs when a number of problems were linked to the choices in the past, effective energy management in this choice was not enough to make decision, and at the moment the problem migrated to another choice. Now remaining in the choice of energy efficient enough to "make a decision" as required to address energy is zero. It is obvious that in the solution of the type «Flight» no problems are not solved.<br>Another type of solution is «Resolution». It is carried out in the case where at this time of the decision rule in the choice of the effective energy managers enough (greater than or equal) to solve the problems associated with this choice.<br>The third type of solution is «Oversight». This decision is carried out when the newly activated choice does not join any problem. Oversight solution does not solve the problem and implemented at minimal cost effective energy acceded to the choice of managers. This energy is wasted, as is spent on the zero solution of problems. The economic substance of such a solution is the discovery of a new committee for which is not relevant issues. Solution «Oversight» typical case of a |

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| | | specialized access and decision structures, since such a structure may be cases activation problems in later times, rather than activation available to them choices. |
| | *Emergence* | The main result observed in the simulation is the behavior of managers pursuing problems moving through the choices. |
| | B.2. Individual decision making (*Adaptation*) | The individual behavior of managers and problems consists in finding the choices that are closest to the solution, that is, having the minimum difference between the required energy to solve problems and the effective energy accumulated in choice. |
| | *Objectives* | Objective is quantity of problems resolved, types of making decisions, state of choices, amounts of effective energy spent on decision making (problem solving).<br>They are measured quantitatively and are available to the survey in the model interface (chart for EE and figures on World window). |
| | *Learning* | Individuals do not learn throw the simulation process. |
| | **B.6. Individual prediction** | Individuals do not predict future condition. |
| | **B.7. Stochasticity** | Initial setting are sources of stochasticity in the model:<br>1. is generated a flow of choices, i.e. random sequence of numbers from 1 to 10 (steps of model time, when choices will be activated);<br>2. is generated a flow problems, i.e. random sequence of pairs of numbers from 1 to 20 (steps of model time, when pair of problems will be activated), i.e. all problems will be generated in the first ten points of modeling time.<br>Stochasticity in model is realized by random settings of sequence of ticks, when problems and choices will be opened. |
| | **B.8. Observation** | Reports:<br>Quantity of problems resolved, types of making decisions, state of choices, amounts of effective energy spent on decision making (problem solving). |
| | B.9. Implementation Details | The model is coded in Netlogo 6.0.4, Open source and available on CoMSES (https://www.comses.net)<br><br>If you mention this model or the NetLogo software in a publication, we ask that you include the citations below.<br>For the model itself:<br>Smarzhevskiy, I., 2014. Garbage Can Model: Reconstruction and Logical Analysis : http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2490388<br>Smarzhevskiy, I., 2014 Four Border Structures in GCM (Small Addition to the 'Garbage Can Model: Reconstruction and Logical Analysis'): http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2519433<br><br>Please cite the NetLogo software as:<br>* Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL. |
| **C. Details** | **C.1. Initialization** | During the initialization process, data is entered for<br>1. Defining the structure of access problems to the elections (two-level list) |

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| | | 2. Defining the structure of access for managers to elections (two-level list)<br>3. Specify the order (number of tick) activation problems<br>4. Defining the order (number of tick) of the activation of elections<br>5. Generating effective energy distribution among managers<br>The initial data is located in code of model. |
| | **C.2. Input data** | The model does not use input data to represent time-varying processes. |
| | **C.3. Submodels** | |
| | **setup** | Do random settings of sequence (schedule) of ticks, when problems and choices will be opened (variables **choice_opens_at**, **problem_opens_at**). Call **set_structure** procedure. Create managers by **open_managers** procedure. |
| | **set_structure** | The procedure is intended to enter the initial data. The initial data is organized in the form of lists containing constants.<br>Global variable (list**) jia** represent problem's access to choices.<br>Global variable (list) **ika** represent manager's access to choices. Global variables **l** and **k** are service characters and are used to index list items. |
| | **open_managers** | Create managers in according with model size. |
| | **go** | Implements the simulation process by calling procedures **open_choice, open_problem, problems_seek_best_choice, managers_seek_best_choice, energy_changes, problem_move, manager_move, decisions?** and control end of experiment after the time has expired or because all the energy (EE) of the managers has been consumed. |
| | **open_choice** | Create choice in according with schedule. Set *Decision type* attribute to "Oversigt". If no problems join this choice, it will be closed with this type of solution. |
| | **open_problem** | Create choice in according with schedule increasing the total energy required to solve them (see Chart "Total current ER"). |
| | **problems_seek_best_choice** | Problem seek choice with min (ER - EE). |
| | **managers_seek_best_choice** | Manager seek choice with min (ER - EE). |
| | **energy_changes** | Transfer quantum of EE from manager to new choice when manager joins to it. |
| | **problem_move** | The problem migrates to the selected choice. The image is updated in the World window. Change decison_type to "Flight". If problems later go away from this choice, it will be closed with this type of solution. Then the effective energy of the managers accumulated in choise is lost (see Chart "EE wasted"). |
| | **manager_move** | The manager migrates to the selected choice. The image is updated in the World window. |
| | **decisions?** | Checks all open choices and when the decision rule (ER < EE) is executed, closes such a choice and all problems attached to it. Displays in the window of the World a message on the development of a decision "Resolution". |
| **References** | | Cohen, M., March, J. & Olsen, J., 1972. A Garbage Can Model of |

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