Electronic Government and Electronic Participation
M.F.W.H.A. Janssen et al. (Eds.)

doi:10.3233/978-1-61499-429-9-95

Automatic Generation of Roadmaps for Open Data

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Abstract. This article presents a model to assess maturity and capabilities of public agencies (PAs) in pursuing the Open Government Data (OGD) principles and practices. The OGD maturity model, called OD-MM, was piloted in seven PAs from three Latin American countries (Chile, Colombia, and El Salvador), validating the web tool that operationalizes the model. The OD-MM is a valuable diagnosis tool for PAs, since it detects weaknesses and automatically generates a roadmap to evolve to higher maturity levels in the implementation of OGD. The automatic generation of optimal roadmap is detailed.

Keywords: Roadmaps, Maturity Model, Open Data, Open Government Data

Introduction

The *Open Government* approach attemps to put data at the disposal of all citizens, which has proven to generate an important public value [[1]]. Lathrup and Rume in their *Open Government* book [[2]] bring up three fundamental concepts for a better understanding of the *Open Data* impact:

- Public Service Information (PSI) is a kind of infrastructure, with the same importance level as other infrastructures (water, electricity, roads).
- Public value must be maximized as of existing data held by government.
- The open data magic is that it enables transparency and innovation.

Several authors have presented different criteria to assess and diagnose the *Open Government Data* (OGD), such as the famous eight principles of OGD [3], the "five stars" test proposed by Berners-Lee [4], the Gartner Open Government Maturity Model [5], the Smart Government Maturity Model in Central and Eastern Europe [6] or the Open Data Readiness Assessment tool created by the World Bank [7], among others. Nevertheless, Kalampokis, Tambouris and Tarabanis in [8] admit that, despite the potential that the various models recently emergent in literature, as those previously presented, there is currently a lack of roadmaps, guidelines and benchmarking frameworks to drive and measure OGD progress.

Hence, there is a need to measure and assess the readiness of public agencies (PAs) to implement OGD and to automatically generate a roadmap. The Open Data Maturity Model (OD-MM) [9] was a result of a project carried out to satisfy this need. The project was developed by the Computer Engineering Department at Universidad Técnica Federico Santa María (Chile) with funding from the Canadian International Development Research Centre (IDRC, www.idrc.ca), and the support of CTIC Foundation (www.fundacionctic.org), the Organization of American States (OAS, www.oas.org), the Inter-American Organization for Higher Education (OUI-IOHE) and Red GEALC (www.redgealc.org). The advantage of the OD-MM is that, as from the diagnosis of a PA it automatically generates the roadmap with recommendations to evolve to higher levels of organizational maturity.

Next section, in a brief summary, introduces the OD-MM maturity model. OD-MM was evaluated and validated by expert public officials from three Latin American governments (Chile, Colombia, and El Salvador) through a pilot study and several workshops, and the model was finally applied to a selection of seven PAs, generating the first formal measurements of their readiness for OGD. Section 2 shows the region-wide diagnosis. Section 3 presents a roadmap generated automatically with recommendations. Last section shows the conclusions.

1. Maturity Model and OGD Capacities

Reggy [10] defines a four levels model for the eight principles, and each of them has a score (0%, 33%, 66%, 100%) according to its level (see Table 1). An indicator assesses the global quality by averaging the score associated to the eight principles. Another model with five maturity levels, called “Methodology for releasing Open Data” (MELODA), covers three dimensions (Table 1). Morgan recommends in his blog developing a three dimensions maturity model and four maturity levels (emerging, practicing, enabling, and leading) [11]. Lee and Kwak in [12] recommend agencies to advance their open government initiatives incrementally in stages, moving from one stage to another as they mature their adoption of open government. The stages are: (1) increasing data transparency, (2) improving open participation, (3) enhancing open collaboration, and (4) realizing ubiquitous engagement. Kalampokis et al. in [8] proposed a stage model for OGD with two main dimensions as seen in Table 1.

Important elements that can be identified in Table 1 and that should be considered when diagnosing the implementation of OGD at PA level are those that stand out in successful cases described in literature ([8], [9], [10], [12]). Among these dimensions the following are important to be considered:

- The **establishment** of a PA, given that the importance of leadership and strategy in OGD initiatives is highlighted in literature.
- The **legal** aspect, allows to having a legal frame when implementing OGD.
- The **technological** perspective as for the accomplishment of OGD principles, such as access to data, data quality and its availability.
- The **citizen** perspective as from participation and collaboration point of view.
- And **developers** and **entrepreneurs** in the reuse of data.

Table 1. Summary of maturity models in OGD

Reference	Maturity levels/stages	Dimensions
Reggy [10]	1. 0% 2. 33% 3. 66% 4. 100%	Eight principles (complete, primary, timely, accessible, machine processable, non-discriminatory, non-proprietary, license-free)
Lee and Kwak [12]	1. Increasing Data Transparency 2. Improving Open Participation 3. Enhancing Open Collaboration 4. Realizing Ubiquitous Engagement	• Public engagement/openness (Value/benefits) • Technical/managerial complexity (Challenges/risks)
Morgan [11]	1. Emerging 2. Practicing 3. Enabling 4. Leading	• Strategy and Policy • Availability • Description & Documentation Practices
Kalampokis, Tambouris and Tarabanis [8]	1. Aggregation of Gov Data 2. Integration of Gov Data 3. (2)+Non-Gov Formal Data 4. (3)+Social Data	• Organizational & technological complexity • Added value for data consumers
MELODA [12]	1. Copyright 2. Private Use 3. Non-commercial reuse 4. Commercial reuse 5. Only recognition	• Legal Framework • Technical Standards • Accessibility to Information

All these elements are considered in the OD-MM developed to assess the capabilities and maturity of PAs in the OGD implementation.

OD-MM is in three levels hierarchically structured: Domain (D_1, D_2, D_3), Subdomain (S_{ij}) and Variables (V_{ijk}). The designed OD-MM incorporates three domains: D_1 - *Institutional and Legal*; D_2 - *Technological* domain; and D_3 - *Citizen's & Entrepreneurial* domain. Each domain has three subdomains (S_{ij} in Figure 1). The conceptualization of 33 variables (V_{ijk} in Figure 1) distributed in nine subdomains is described in [9]. Four capacity levels, from 1 to 4 (Inexistent, Emerging, Existent and Advanced), were established to assess the capacity in each of these variables.

The OD-MM model was validated in conceptual terms by government representatives of Chile (Ministry of the Dept. of Presidency), Colombia (Ministry of Information Technologies and Communications), and El Salvador (Dept. of Technologic and Information Technologies Innovation), civil society and open data application developers (Foundation Intelligent Citizen). Next step was the implementation of the web tool for data survey that the model needs for its validation through a pilot [14]. The experience of applying a pilot to a small set of seven PAs in three Latin American countries, gave the base to assume the weaknesses detected in the diagnosis of these PAs, and propose the actions as a guide to reach level three of maturity, or very close to it [15].

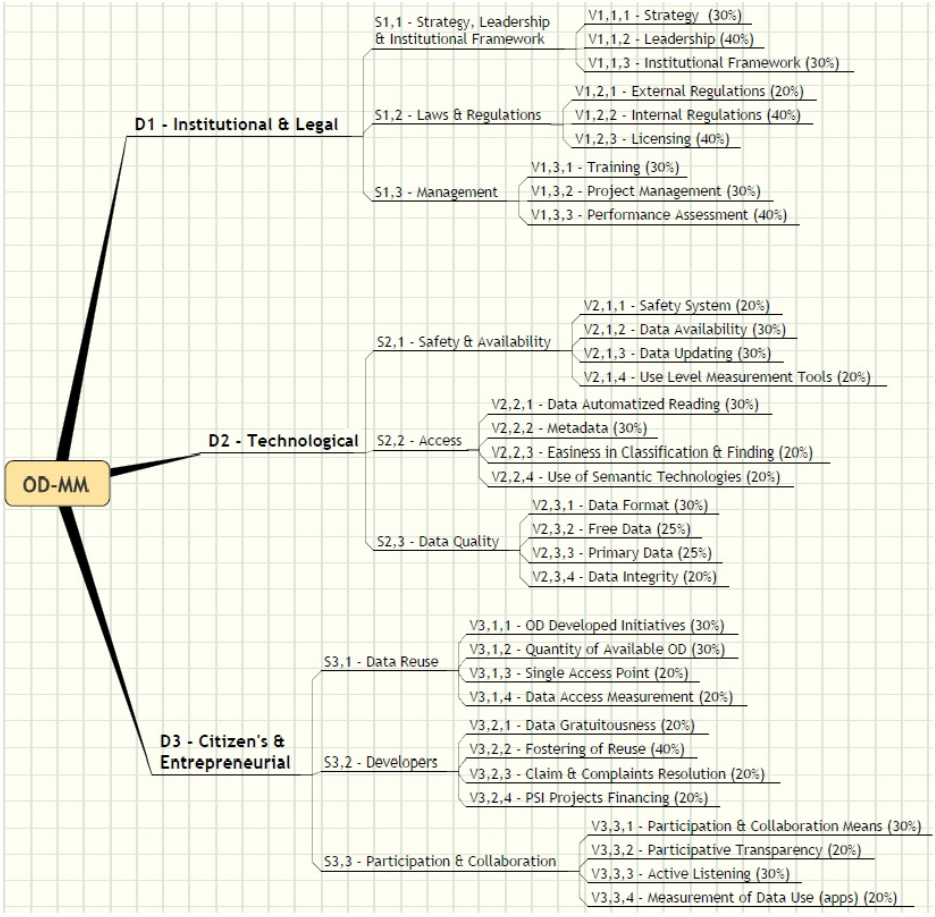

Figure 1. Hierarchical OGD: Domains, subdomains and weighted variables

1.1. Capacity Level (CL) of Variables and Subdomains

Weights (w_{ijk}) of variables (V_{ijk}) for OD-MM model, determined by means of a methodology detailed in [9], allowed to establish the weight for each subdomain. Thus, the capacity level (*CL*) of a subdomain S_{ij} turns out to be a weighted sum (w_{ijk}) of their constituent *CL* variables (V_{ijk}), according to Equation 1.

$$CL(S_{ij}) = \left\lfloor \sum_{k=1}^{n} CL(V_{ijk}) \times w_{ijk} / 100 \right\rfloor \tag{1}$$

Figure 1 shows the weight of every variable in each subdomain of the defined domains. In this way, 100% of a subdomain weight is distributed among the variables it is composed of, i.e., *External Regulations* ($V_{1,2,1}$ with weight $w_{1,2,1}$=20%), *Internal Regulations* ($V_{1,2,2}$ with weight $w_{1,2,2}$=40%), and *Licensing* ($V_{1,2,3}$ with weight $w_{1,2,3}$=40%).

1.2. Organizational Maturity Level (ML)

For each subdomain an incremental measurement scale exists based on a score from 1 to 4. This scale is associated with a generic qualitative capacity model described below.

Level 1: Inexistent Capacities

- Capabilities do not exist or the subdomain is approached in an ad-hoc and reactive manner, tends to be applied on an individual case by case way.
- There is evidence that the subdomains are recognized and need to be approached.

Level 2: Emerging Capacities (informal)

- An intuitive regular pattern to approach the subdomains is followed. Different people follow similar procedures to approach the same task.
- There is no formal training or divulgation of procedures, and responsibility to follow them up rests on each individual.

Level 3: Existent Capacities (formal)

- The procedures related to the subdomains are defined, documented and communicated.
- There is a formal training to support specific initiatives related to subdomains.
- Procedures are not sophisticated; they rather are the formalization of existing practices.
- Monitoring and measuring of compliance with procedures is possible, as well as taking actions when the apparent subdomains do not effectively work.
- Standards and guidelines established apply throughout the whole organization.

Level 4: Advanced Capacities

- Procedures have reached the level of best practices and continuous improvement is applied.
- The use of standard or world-class tools helps to optimizing the subdomains.

Table 2 shows the sets of priority subdomains used to obtain the organization maturity as from subdomains capacity level (*CL*). The advantage of this mechanism is its flexibility, since it only establishes a minimum group of subdomains, important in a given maturity level (*ML*). Country-wide, it allows regulating progresses according to an OGD national strategy, while the rest of subdomains are left to the discretion of the own organization. In this way, a PA will be in *ML* two if only if all the five subdomains (according to Table 2) are in *CL* two (i.e. $S_{1,3}$ - *Management*; $S_{2,2}$ - *Access*; S_{31} - *Data Reuse*; $S_{3,2}$ - *Developers*; and $S_{3,3}$ - *Participation & Collaboration*). It doesn't matter in which CL are the other subdomains, this PA will be in *ML* two, but if any of these five subdomains is in *CL* one, then the ML of this PA goes immediately to one.

Table 2. Organizational maturity estimation based on a set of priority subdomains

S_{ii}	ML 2	ML 3	ML 4
$S_{1.1}$		2	3
$S_{1.2}$		3	4
$S_{1.3}$	2	3	4
$S_{2.1}$		2	3
$S_{2.2}$	2	3	4
$S_{2.3}$		2	3
$S_{3.1}$	2	3	4
$S_{3.2}$	2	3	4
$S_{3.3}$	2	3	4

2. Pilot Study

2.1. Pilot Sample

Ten PAs participated in a sampling of the pilot validation of the proposed model, in three countries that attended and validated the OD-MM model design. From these ten PAs invited in Chile, Colombia, and El Salvador, seven responded to the pilot.

2.2. Pilot Results

Table 3 shows the results of a survey carried out between January and March 2012, in which attendees answered a web questionnaire, according to its role in each of the three domains. This table displays also the capacity levels by subdomain, in each of the PAs taking part in it. Applying Equation 1 in each PA made possible to obtain the *CL* value by subdomain. Six of the participant PAs responded three areas (PA6 was the exception, responding only one domain, the Technological one). The last column shows the CL average in the PAs by subdomain.

Capacity values emphasized in grey color show they are higher than the average of the subdomain; this is a way to highlighting these extreme cases. On one side, the average of subdomain *Developers* is 1.7, and four PAs have a higher *CL* than that average. The case of PA2 stands out, since its assessment in this subdomain is the lowest as institution. Not a single PA is in level three or four of capacity, which coincides with present circumstances.

At the other end are those subdomains (*Management* and *Access*) with only one PA above the average (PA2). All the others are below the average. In the case of *Management*, all PAs are in level one, with the exception of PA2 which is in level two; although its evaluation is the lowest, it is the highest one in the group.

Subdomains *Participation & Collaboration*, and *Access* are the only subdomains with greater dispersion, with levels of assessment between 1 and 4. In the case of *Participation & Collaboration*, three PAs obtained level 1; one obtained level 2, and two obtained level 4. In the case of *Access*, one solely PA obtained level 1, four of

them obtained level 2, and only one got level 4. We believe that these subdomain variables (*Participation & Collaboration Means*; *Participative Transparency*; *Active Listening*; and *Measurement of Data Use-applications*) were misunderstood, since dispersion does not fit to the reality observed.

Table 3. CL of subdomains for PAs participating in the pilot

Domain	Subdomain	PA1	PA2	PA3	PA4	PA5	PA7	CL_{SD}
Institutional	Strategy, Leader & Inst. Framework	3	3	1	3	1	2	*2.2*
&	Laws & Regulations	2	3	1	2	1	1	*1.7*
Legal	Management	1	2	1	1	1	1	*1.2*
	Domain Average	*2.0*	*2.7*	*1.0*	*2.0*	*1.0*	*1.3*	
Technological	Safety & Availability	2	3	2	2	3	2	*2.3*
	Access	2	4	1	2	2	2	*2.2*
	Data Quality	2	3	2	3	2	1	*2.2*
	Domain Average	*2.0*	*3.3*	*1.7*	*2.3*	*2.3*	*1.7*	
Citizen's	Data Reuse	2	3	1	2	1	1	*1.7*
&	Developers	1	2	2	2	1	2	*1.7*
Entrepreneurial	Participation & Collaboration	1	4	1	4	2	1	*2.2*
	Domain Average	*1.3*	*3.0*	*1.3*	*2.7*	*1.3*	*1.3*	
	Average by PA	**1.8**	**3.0**	**1.3**	**2.3**	**1.6**	**1.4**	**1.9**

Table 3 shows each domain simple average by PA. In all cases, this average is always above or equal to the respective *CL* domain in that PA. In case of PA2, was the only PA obtaining a level 2 of institutional maturity, observations point out that its domains averages 2.7 (*Institutional & Legal*), 3.3 (*Technological*), and 3.0 (*Citizen's & Entrepreneurial*). These results provide a global average of 3.0; that is to say, with a 100% compliance for level three of maturity, but when applying the pattern of the Table 2, the institution remains in *ML* two.

Carrying out this same analysis for PA4, it is observed that all subdomains have a simple average above or equal to 2, namely 2.0 (*Institutional & Legal*), 2.3 (*Technological*), and 2.7 (*Citizen's & Entrepreneurial*), but when applying compliance pattern of Table 2, PA4 reaches a level one of maturity. However, to reach *ML* two (Table 2), it should only evolve one level in subdomain *Management*.

Table 3 indicates the capacity average value in each subdomain for the PA representative portion that participated in the pilot of the model and the web tool. The most developed subdomain is *Safety & Availability*. This result matches with the emphasis made generally by governments, in having IT infrastructure available, since all subdomains of the *Technological* domain (*Safety & Availability; Access;* and *Data Quality*) are better-developed than other subdomains [14].

The less-developed subdomain is *Management*. This result allows suggesting the hypothesis that the efforts to introduce OGD in PA do not coincide with formalization of internal processes, development of human capital required and performance assessments. This usually results in inefficient uses of financial resources and additional effort of human capital. Another element to consider is that the average value of all subdomains does not reach level three (Existent).

3. Roadmap Generation

OD-MM model application allows knowing the diagnosis of a PA, but it also proposes improvement instances on these matters (roadmaps). That is to say, it offers an orientation to objectively canalizing financial and human capital resources of an organization that needs to improve its capacities to carry out OGD initiatives. A roadmap should be optimal in relation to the effort required by a PA to achieve a higher *ML*, i.e. it should give a path that represents the lesser effort to the PA. The roadmap to be generated must meet the following requirements:

- Comply with restrictions on the configuration of priority subdomains in Table 2.
- The smallest possible increase of variables to deliver an optimal solution with the least possible effort.

For the latter condition is defined that the variable to be increased should be as important as possible, so that the choice of the candidate variable to improve is as follows:

- A variable is chosen with the lowest *CL*.
- A variable is chosen with the highest weight.

The first constraint above ensures that the evaluated PA will improve its weakest points, in addition to the least possible effort. It is understood that to increase a *CL* of a variable from *i* to *i*+1 represents a less effort than increasing the *CL* of the same variable from *i*+1 to *i*+2, due to a higher *ML* demands a greater effort. The algorithm to generate the roadmap sorts the set of variables V_{ij} in ascending order according to their capacities. In this way, the operation `Get` a variable from that set, will return the variable with the lowest *CL* (Figure 2).

The second constraint ensures that the most important variables are those that must be met first. Each variable has a weight representing its importance within the subdomain. Due the way in which the *ML* of a PA is calculated, increasing the *CL* of a variable with a weight of 40 % is the same as increasing the *CL* of two variables with a weight of 20 % each, but increases of one variable means less effort than increasing two variables for the PA. In this way, if there are two or more variables with equal *CL*, the algorithm in Figure 2 sorts these variables in descending order according to their weights.

If you have two or more variables candidates to choose from, and as you want to increase the value of one of these, you can select one at random, as they have the same level and weight there is no way to know which of these is more important or represents a lower effort to PAs.

Table 4 describes the variable *Project Management* to all capacity levels. The selection carried out by PA2 for variables *Project Management* (bolded in Table 4) and *Performance Assessment* was level 2, and level 3 for variable *Training*. When applying Equation 1, calculation of weighted sum of variables for subdomain $S_{1,3}$ - *Management*, the result of Equation 2 shows that $S_{1,3}$ is in a *CL* 2, but has a 30% capability from the third level, therefore, an optimum *roadmap* must increase the *CL* of the subdomain in a 70% and not in a 100%.

$$CL(S_{1,3}) = \frac{2*40 + 2*30 + 3*30}{100} = \frac{230}{100} = 2.3 \quad (2)$$

```
Algorithm Roadmap Generator(CL(V_ijk) of PA)
begin
For each subdomain S_ij calculate
   CL(S_ij) = ⌊ Σ_{k=1}^{n} CL(V_ijk) × w_ijk /100 ⌋
m = ML according configuration of CL(S_ij); m=(1,2,3,4)
if (m == 4)
then No Roadmap is required
else
  begin; generation of roadmap from ML m to ML m+1
  repeat
    S_ij S / CL(S_ij) less than required in ML m+1 (Table 2)
    /* S: set of all subdomains S_ij needing improve
    V_ijk V_ij / CL(V_ijk) less than required in ML m+1 (Eq. 2)
    /* V_ij: set of all variables V_ijk S_ij needing improve
    Sort V_ij in ascending order of CL(V_ijk)
    if (there are V_ijk with the same CL)
    then  Sort V_ij in descending order of w_ijk
    repeat
      Get a S_ij S and remove it from S
      repeat
        Get a V_ijk V_ij and remove it from V_ij
        Increase CL of V_ijk
      until V_ij==Φ or CL(S_ij) is achieved
    until S==Φ
  until ML m+1 is achieved
  Generate Roadmap with augmented variables
  end
end.
```

Figure 2. Algorithm to generate an optimal roadmap

If the institution has *ML* 2, then the roadmap generated points out to achieving capacities of *ML* 3, and from *ML* 3 is generated a roadmap to *ML* 4 that belongs to Advanced Capacities. From Table 2, PA2 postulates to institutional *ML* 2, since when *Management* subdomain is in *CL* 2, it does not reach institutional *ML* 3. Table 3 shows that subdomain *Strategy, Leadership, & Institutional Framework* has a *CL* 3, which exceeds the requirement in reference level for *ML* 3 in Table 2. *Laws & Regulations* meets with the *CL* required for *ML* 3, and *Management* must improve its *CL* from 2 to 3, in order to reach *ML* 3 as institution.

The generated roadmap is equivalent to the elements recommended to develop in the institution the capacities to reach *ML* 3. In this case, these recommendations are directly obtained from the descriptions of *CL* 3 of variable Project Management in Table 4.

Table 4. CL description of variable "Project Management"

CL	Variable: *Project Management (30%)*
Level 1	Although its importance is recognized, management of these projects is only according to specific skills of the Project Director on duty.
Level 2	**Only certain projects have been managed with established procedures.**
Level 3	A PMO (Project Management Office) exists that ensures the compliance of standard procedures when managing all OGD projects of an organization. Alignment of projects considers business targets.
Level 4	Carry out systematically specific training in Project management. The organization has a PMO using market standards such as those proposed by Project Management Body of Knowledge of PMI (Project Management Institute) or other equivalent. The organization has special care of cautioning that OGD principles do absorb other related projects.

The roadmap generated to improve variable Project Management has the following recommendations:

- Manage projects with established procedures.
- Create a PMO to ensure compliance of standard procedures in all OGD projects management.
- Align projects with business target.

The experience of having a diagnosis and its respective roadmap in each PA, allow to propose an OGD implementation guide to assume weaknesses detected in the diagnosis of PAs [14]. Therefore, when following the actions proposed by the guide in [15], institutions will reach level 3 of maturity, or very close to it (from a maximum of 4), for sure.

4. Conclusions

The OD-MM approach, model, and web tool grant several contributions to the adoption and improvement of OGD implementation in public agencies:

- It is the first especially developed model used as a basis by developing countries.
- It allows PAs to carry out a self-assessment through a web-based tool for simplicity and wider availability. None of the other models has this feature present.
- Simple and fast to use, since self-assessment tool does not require special technology training, and is freely available.
- Each application of the model automatically generates a roadmap with recommendations to evolve to higher maturity level.

Acknowledgements

The authors would like to thank Gonzalo Valdes, Gastón Concha, Cristián Torres, Luis Meijueiro and José Gleiser for their work in the project. This work was partially supported by the grants DGIP 241142, International Development Research Center (IDRC/CDRI) with the collaboration of Inter-American Organization for Higher Education (OUI).

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