Setting Up Government 3.0 Solutions Based on Open Source Software: The Case of X-Road

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Abstract. Government 3.0, which builds on openness and transparency, sharing, increased communication and collaboration, government reorganization through integration and interoperability, and use of new technologies, is an emerging concept in eGovernance. However, few systems that qualify as Government 3.0 have been described in detail so far. And there is a lack of research on how governments can put in place such systems. This study investigates and characterizes an innovative eGovernment project, based on Open Source Software (OSS), that could be considered as an example of a Government 3.0 project. Therefore, we report from a case study of X-Road, an originally Estonian eGovernment project for creating a data sharing infrastructure, which today is also used in other countries. We present the main characteristics of X-Road from the point of view of Government 3.0, how the X-Road project is organized, compare its organization to other OSS projects, identify who contributes to the project, and point out what challenges are perceived by their stakeholders. We conclude offering some reflections on how X-Road and other Government 3.0 projects can benefit from OSS.

Keywords: eGovernment · Government 3.0 · Open Source Software · Platform · Interoperability · Community

1 Introduction

Government 3.0 has been proposed recently as a concept to describe the next generation of services and solutions offered by governments [28]. Although there is no widely agreed definition of what Government 3.0 means and supposes, there is agreement that it is based on openness and transparency, sharing, increased communication and collaboration, government reorganization through integration and interoperability, and use of new technologies [29].

Although there are few examples of what could be considered a Government 3.0 solution, there is some previous research that has already offered and discussed one, the Finnish Suomi.fi platform [38]. In this paper, we report on an

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investigation of how Governments can set up Government 3.0 solutions through the analysis of the X-Road project. X-Road comprises a data exchange layer solution which empowers different organizations to exchange data and information over the Internet and ensures confidentiality, integrity and interoperability between data exchange parties. X-Road is a central part of the Estonian eGovernment services and has been so for more than 15 years [16,18]. It offers the main infrastructure for the Estonian e-Residency [20] and is being used, among others, in health-care [35] and e-voting [36]. The Finnish Suomi.fi initiative mentioned above is also backed by X-Road [38].

An important characteristic of X-Road is that it has been conceived to be widely adopted, mainly by other states. So, together with the Finnish government, Estonians merged efforts in the Nordic Institute for Interoperability Solutions (NIIS) to foster X-road and related technologies. X-Road is provided as Open Source Software (OSS)[1], first under the European Union Public License and more recently under the MIT open source license[2]. While the involvement of governments in OSS is not new, X-Road can be considered as a new scenario, given that the requirements for Government 3.0 solutions require a different approach by Governments. For these reasons, we find that X-Road constitutes an interesting, and somewhat unique, initiative which motivates investigations and detailed scrutiny.

In particular, the overarching research goal pursued in this study is to characterize how a Government 3.0 solution can be (and is being) implemented through the deployment of the X-Road OSS project.

The study investigates four specific research questions (RQs):

- RQ1: What are the main characteristics of X-Road?
- RQ2: How is the organizational structure of X-Road and how does it differ from other OSS projects?
- RQ3: Who are the contributors to X-Road and what are their roles?
- RQ4: What challenges do different stakeholders of the X-Road project perceive?

The structure of this paper is as follows: In Sect. 2 we offer related research. Next, in Sect. 3, we present the research approach used in this study. Section 4 reports on the results of answering the four research questions. Finally, Sect. 5 discusses our results and contributions, and concludes the paper.

2 Related Research

Governments have led many initiatives regarding OSS in the past. Among these, we can point out the creation of infrastructure to enable sharing among different public institutions [12] or a wide legislative effort to adopt and sometimes

[1] Software provided under the terms of an OSS license allows use, modification and redistribution.

[2] https://opensource.org/licenses/MIT – Accessed 2019-03-15.

embrace OSS [25]. Governments have had interest in the adoption and use of OSS solutions [22,33]. Notably, there are many papers on the advantages of adopting OSS in governments [14,21] and how OSS technologies can be used to restructure the Public Sector [11] and develop new eGovernment services [17]. Other actions related to OSS by governments are OSOR.eu (an OSS sharing system for e-government solutions in the EU [13]) or the many OSS observatories [5]. The use of OSS in the public sector is not without its challenges. ICT procurement still is a burden to the use of OSS and open standards [23], and not infrequently the adoption of OSS in the public sector comes after difficult negotiations and the fulfillment of special conditions [34].

The nature of OSS projects contributes to the formation of communities around them. Several scholars have studied their social structure. One of the models that has been widely used for describing the roles of OSS participants is the so called "onion" model [4]: the most contributing developers are in the center of the project (the "core" developers), *surrounded* by a new layer of occasional contributors. In an outer layer, we can find the *end users*. The further away from the center, the less contributions and influence a person has in the project. For large OSS projects, the outer layers outnumber in orders of magnitude the inner ones. Projects are then considered to have a surrounding community of users and developers, which has many positive effects on the project [31].

X-Road has been a matter of study, or at least referenced, in several works in the research literature. The functional structure and economic advantages of the X-Road project were early emphasized in an effort to modernize the national databases of Estonia [16]. Paide et al. recently studied the systematic exploitation of the X-Road for strengthening Public-Private partnership, and specifically, in light of the limited private sector interest in X-Road so far, how to "make a platform more acceptable for both public as well as private entities" [30]. X-Road fosters interoperability. The importance of interoperability in a eGovernment context has been highlighted since many years ago [10], showing it to be a crucial aspect of the services that many governments want to offer [19,27]. A recent report by Inera with a focus on national interoperability has analysed how existing solutions in Sweden relate to X-Road and elaborates on challenges and issues that need to be addressed prior to adoption of a national IT solution for data exchange in Sweden [15].

3 Research Approach

To pursue our research goal and address the RQs, we report from a case study on the X-Road project. Benbasat et al. consider that "[a] case study examines a phenomenon in its natural setting, employing multiple data collection methods to gather information from a few entities. The boundaries of the phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used" [1]. Therefore, a mixed-methods approach has been used in this research [3], combining qualitative and quantitative data sources to offer a more complete perspective of the project, based on the analysis of publicly available sources and by means of interviewing relevant stakeholders of the X-Road project.

3.1 Analysis of Publicly Available Sources

Two different types of publicly available sources were analyzed.

- *Public documents:* We collected secondary data from the NIIS web news articles and blog posts that were written about X-Road. The number of collected secondary data was more than 100 items.
- *Publicly available Open Source project and related artifacts:* X-Road's source code can be obtained from an open collaborative platform[3] since mid-2015. We have analyzed the version control system where the history of the sources are stored with the help of a tool called Perceval [6], in order to obtain the individuals who have contributed code to the project.

3.2 Interviews

In order to gain first-hand insight from the project participants on the project, we performed a number of interviews. We decided to perform open interviews based on a set of questions prepared in advance, which were supplemented with additional questions as the interview progressed. According to Walsham, "[i]nterviews should be supplemented by other forms of field data in an interpretive study, and these may include press, media and other publications on the sectoral context of the organizations being studied. Internal documents, if made available, may include strategies, plans and evaluations. Direct observation or participant observation of action is a further data source" [37].

The goals of the interviews are (i) to validate our previous observations gathered from documents, web pages and videos, and (ii) to obtain additional, relevant information on X-Road and its organization in order to supplement already collected data, to thereby further enrich the analysis.

Therefore, we designed questions that helped to achieve these goals. In particular, the questions were related to the following areas: (i) participant's role, aim and experience, (ii) aims of the project, (iii) roles in the project, (iv) organizational structure of the project, and (v) perceived challenges of the project.

Given the nature of the interviews, not all questions that where prepared in advance were asked, as the natural flow of the conversation resulted in the interviewee addressing at once more than one question. Also, related to some questions, follow-up questions were asked in order to probe further as the interview session progressed.

We have performed purposeful sampling when inviting interviewees, based on the results of RQ2 and RQ3. So, we first classify the different groups of stakeholders in X-Road (RQ2: How is X-Road organized?), and then we identify for each of the groups interview candidates (RQ3: Who are the contributors to X-Road?). As a result, we have interviewed one stakeholder working at NIIS, another one being contractor of NIIS, and 4 among the rest of stakeholders (three former software engineers affiliated to companies offering services based on X-Read, and one end user). The rationale for this selection will become clear

[3] https://github.com/nordic-institute/X-Road – Accessed 2019-03-15.

when we present the results of RQ2 and RQ3, and is related to the fact that the source of the 'official' information on web and documents is NIIS (and its contractors), so the amount of new information and the additional insight we gain from interviewing them is lower than for the rest of the stakeholders.

The interviews were performed over *confcall* (Skype or Google Hangout). Interviews were recorded and transcribed in order to aid analysis.

4 Results

The results to the RQs are presented in the following four subsections.

4.1 Characterizing X-Road

Figure 1 presents an overview of the X-Road data exchange framework and its purpose. Instead of building a centralized, very big database with all data (a very complex, risky and costly alternative), Estonians chose for creating a framework to support and facilitate data exchange between databases over the Internet. X-Road serves as a data exchange bus between many databases that implements a set of common features to support and facilitate data exchange. All data exchange is secure, as all outgoing data from X-Road is digitally signed and encrypted, and all incoming data is authenticated and logged. The transversal nature of X-Road makes it possible to not only offer services from Governments, but invites as well participants from the private sector [30].

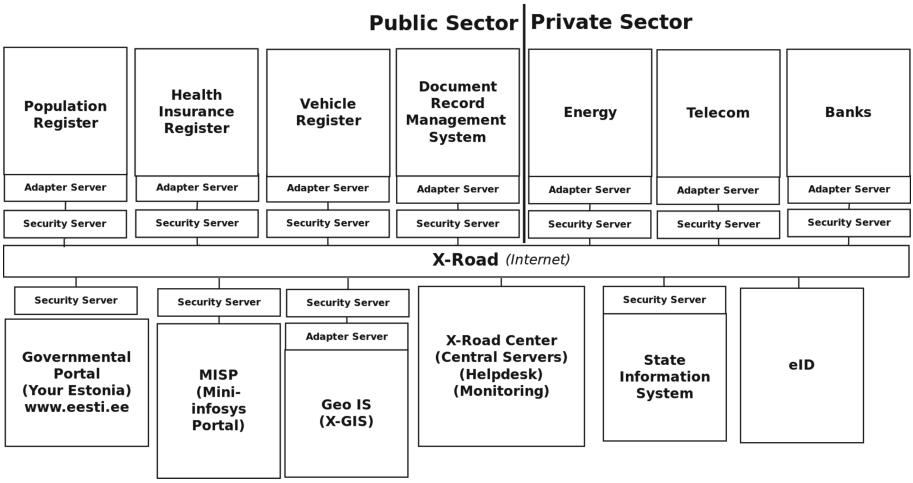

Fig. 1. X-Road data exchange framework (Adapted- Original: World Bank - bit.ly/2WcIDB5)

The purpose of NIIS is to be "both a network and cooperation platform, and executioner of IT developments in members common interests. This is probably

the first time in the world when a joint special purpose organization of two countries develops a OSS using agile software development methods." NIIS does not offer consultation services nor support for deploying independent X-Road instances. The X-Road website lists at this time five companies (three Finnish and two Estonian) who can be contacted on these matters.

As a result, we have observed that X-Road aims mainly to be an interoperability solution, that goes beyond just the public sector, and involves as well the private sector. To increase the adoption of such a solution, the X-Road project is released under a OSS license, so that use and reuse can be maximized. This way, the project addresses the problem of deployments being different in every country. This is because countries usually have a different usage context, as data and regulations are different from country to country.

4.2 Organizational Structure of X-Road

X-Road is a growing community[4]. It has been reported that X-Road in Estonia currently has 671 institutions and enterprises, 516 public sector institutions, 52,000 organizations are indirect users of X-Road services, 1620 interfaced information systems, 2706 services that can be used via X-Road, and 372 security servers installed by members[5]. X-Road is also implemented in Azerbaijan, Namibia and Faroe Islands[6].

The Department of State Information Systems of the Ministry of Transport and Communications in Estonia was initially governing the development of X-Road (known as "X-tee" in the Estonian context). A new governance regime was initiated in 2017 when the Estonian and Finnish governments established the Nordic Institute for Interoperability Solutions (NIIS) in a joint effort for further development of the X-Road project. The purpose of NIIS is to be "both a network and cooperation platform, and executioner of IT developments in members common interests"[7]. This may be the first time in history that a joint special purpose organization involving two countries governs an OSS project. Iceland became a partner of NIIS in September 2018.

Concerning NIIS, its highest body is "the General Meeting of its Members. The Members of NIIS are the Ministry of Finance on behalf of the Republic of Finland and the Ministry of Economic Affairs and Communication on behalf of the Republic of Estonia." and it "is managed and represented by the Management Board"[8]. The Management Board is elected for three years and may have one to three members. The members of NIIS have agreed that the Management Board shall comprise a single member who shall act as the Chief Executive Officer of the Institute. The CEO is in charge of the day-to-day management of the Institute. Further, NIIS has an advisory group which "is formed for the

[4] X-Road community portal: https://x-road.global/ – Accessed 2019-03-15.
[5] https://www.ria.ee/en/calendar/anniversary-x-tee-2018.html, Accessed 2019-03-15.
[6] http://e-estonia.com/solutions/interoperability-services/x-road, Accessed 19-03-15.
[7] https://www.niis.org/data-exchange-layer-x-road/, Accessed 2019-03-15.
[8] https://www.niis.org/organization-and-management/, Accessed 2019-03-15.

purpose of supporting the Chief Executive Officer and relaying information and instruction between the operative level and the General Meeting. For clarity, the Advisory Group is not a formal organ of the Institute and has no decision-making power on its own".

The technical requirements in X-Road stem from the NIIS members (currently Finland and Estonia), as NIIS is based on them. The technological decisions are taken by NIIS, as well. When it comes to strategic decisions, the CTO is the one responsible for them, although they are discussed internally at NIIS (and consulted with the Finish and Estonian governments).

All in all, from our analysis of the X-Road project we conceptualize three layers in the organization of X-Road. In the center, being in charge of the strategic decisions and of the funding of the project, we have NIIS with its member states. A second layer is formed by contractors, who develop the system and/or deploy it in the different contexts. Contractors depend financially from NIIS, although they can offer services to the private sector as well. Finally, a third layer is composed by users and external developers, usually affiliated to companies who offer services around X-Road, some of these being former contractors.

A first difference to other forms of organization found in OSS projects is that their members are usually individuals or organizations/companies – in the case of X-Road, only countries can be members, although partnership is offered to private companies. Iceland is partner at the moment, although NIIS hopes that it will become a member in the near future. The aim in the near future is to find new countries to join NIIS and participate.

A second difference lies in the fact that in OSS projects, a central group of developers (known as the *core*) is the one responsible for a large majority of the actions – in the case of contributions to the code, the share of the core group usually ranges from 80 to 90% [32]. In X-Road, the central role is played by NIIS. But its contribution to the code is very limited, as this is mainly done by contractors.

A third difference is who takes the decisions. In X-Road, although there is no strict control in place of the development as stated by one of the contractors, the final decision -be it technical or not- is taken by NIIS. In comparison, in other OSS projects these type of decisions are taken by the developers (e.g., in GNOME [8]) or by low-level committees (e.g., Apache [7]). One of the external consultants interviewed, deepened in this situation. He stated that his company had launched a proprietary product that reimplemented X-Road from scratch, based on their experience of designing and implementing X-Road for years. This could be seen as a *fork*, an independent branch of the software that evolves independently (i.e., the developer teams and those who take decisions differ) [31]. Forks are intrinsic to the OSS licensing model, so they are not illegal. However, they are seen usually negatively as they duplicate efforts and often produce unnecessary tensions. In the opinion of this interviewee, their *fork* -even if it has a proprietary license- is more *open* to participation and is making progress in building a community than the X-Road project.

All in all, we see that X-Road deviates from the classical onion model found in OSS projects. The economic, decisional and strategic power resides in the center (NIIS and its members), but in comparison to what we find in OSS projects, it is not the main driver of (development) activity of the project. The development activity is mainly performed by an outer layer, contractors who financially depend on NIIS. Other stakeholders (including users) are in the outer layers, and have few control and decision power, even concerning minor decisions.

4.3 X-Road Contributors and Their Roles

X-Road and associated components are hosted on an open collaborative platform[9] to allow for world wide contributions from individuals and organizations. In total, 32 individuals have contributed to X-Road core from 2014 (based on analysis of author identifiers) until December 2018 (whereof 26 authors have made more than a single contribution). The five most active contributing individuals are Ilkka Seppälä (Gofore Oy, 305 contributions), Jarkko Hyöty (Gofore Oy, 230 contributions), Toomas Mölder (Republic of Estonia Information System Authority, 108 contributions), Joni Laurila (Gofore Oy, 107 contributions), and Tatu Repo (Gofore Oy, 96 contributions). There are 11 different organizational affiliations for committers (based on assessment of author email domains). The five most active contributing organizations are Gofore Oy (923 contributions), Cybernetica (133 contributions), Republic of Estonia Information System Authority (122 contributions), NIIS (56 contributions), and Qautomate Oy (42 contributions).

We asked interviewees the different roles that exist in the X-Road community. This does not only allow to compare their point of view with the roles that we had identified previously, but we also hypothesized that it could offer insight into how they perceive the community. To our surprise, we obtained a variety of responses. Interestingly enough, the organization who leads X-Road and the end-user offered a simpler model of the community, with less roles. So, according to NIIS, there are three different types of roles:

1. NIIS members: currently Estonia and Finland (with operator organizations responsible of running X-Road at the national level)
2. NIIS partners: currently Iceland and other organizations exchanging data (public bodies, private companies)
3. Citizens: those using servers, anyone can be member of that community (informally).

For end users, the picture is similar, although the differentiation is between public bodies, the private sector and citizens. This is understandable as end-users are not that much aware of the organization and participation in the community, and simplify these matters. For them, the prominent aspects are that the technology works, that it is free and gratis (not necessarily in that order).

[9] https://github.com/nordic-institute/X-Road, https://github.com/jointxroad – Accessed 2019-03-15.

It is other developers and external consultants who offer a much diverse community, much more in line with the identification of roles that we had performed. They see X-Road as a project with more actors, a sign that they see more opportunities in the X-Road project.

4.4 Challenges

Several challenges have been identified from the analysis of the interview responses.

We find that the current onboarding process is complex based on the analysis of the responses. New developers who want to contribute have to face a steady learning curve. In addition, very few vendors have experience and knowledge on X-Road and its technologies.

According to NIIS, the private sector is involved, primarily in Estonia. Several companies provide services (development, support, deployment, consulting, maintenance). However, no source code contribution so far has been received from the private sector. External developers and consultants have pointed out other initiatives where companies have used X-Road in their business strategy in many countries, far beyond Estonia and Finland.

Even if there is interest in many countries, the pace at which Governments move forward is slower than other organizations. The interviewees note that there is a lot of political *wheel*, and that a lot of explanations and consultations are to be expected for any new member to join.

From the point of view of strategic challenges, the nature of NIIS makes the project heavily dependent on its member countries. It has to be said that at the moment, all interviewees see a strong political support and do not expect this to be affected by a change in government in the near future. All respondents perceive that the support is so strong that this is independent of the political party that will be in the government.

5 Discussion and Conclusions

X-Road is an important project to investigate, not only because of its technological innovation, but as well because of its organizational structure. The fact that the members of the project are countries is novel in OSS. This also influences the type of organization that drives the project, how the strategy is considered and decisions are taken.

From the public documents and information that we have analyzed, and based on our analysis of observations, experiences and insights we have obtained from the interviewees, we have reflected on the goals that the X-Road project pursues. Thus, we have identified following goals: (i) to set up an interoperability solution, ready for being used by the public and private sector (the X-Road framework), (ii) to offer an OSS software that implements the aforementioned solution (the X-Road project), and (iii) to create a community of stakeholders, from the public and private sector, but as well final users/citizens.

In comparison to other OSS organizations, we find that X-Road has a more rigid structure. In addition, although other organizations try to have a structure that is more flat, in X-Road we note that strategy and decisions are mostly top-down. This makes sense and is aligned with the (political) priorities, and can be seen by the project structure. However, it has as well its potential drawbacks, as the creation of a community is not promoted in such a way as other OSS projects do, including those that are driven by a single company or a consortium of companies [9]. We acknowledge that NIIS has taken various initiatives for online training in order to promote the broader X-Road community.

We have found that different experiences and views emerged from the interviews. So, while for NIIS, the organization in charge of its development and promotion, see X-Road as a project, the companies that are active in the project (as a subcontractor of NIIS or as external consultants) see X-Road as a more complex structure, with elements that make X-Road be conceived as a software ecosystem [26] (i.e., initiatives around X-Road beyond the *official* one exist). Further research should address the fact that Governments may want to create not only technology infrastructure, but how to offer opportunities for the private sector to embrace the effort. In this sense, we see *forking* as a less sensitive issue, if interoperability and a healthy ecosystem (probably with all software being OSS) is maintained.

It is noteworthy to see that one of these initiatives has resulted in a derivative project - with the intention to become a fork. The permissive license of X-Road allows for further creation of proprietary solutions from vendors. It is our understanding that the current organizational structure of the project would have benefited from a copyleft license, as this would imply that third party vendors (basically companies) have to distribute their enhancements under the same license. In this regard, based on the analysis and prior experience from implementation of specifications for data exchange in other domains [24], we conjecture that the LGPL license would have been a feasible alternative [2], and we consider that appropriate license choice for X-Road needs further investigations.

In this study we have conducted a single case study, with its particularities and peculiarities. Rich insights and experiences from those involved with X-Road and NIIS provide valuable findings which can be transferred to other similar contexts. However, we cannot claim that our results can be generalized to all contexts.

In conclusion, we have investigated the X-Road project, an OSS project that is led by an organization created by two countries. The nature of X-Road is of interest because of its organizational structure. By means of six interviews to several stakeholders holding different roles in X-Road we have gained some insight into the nature of the project.

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