A case study of the public sector digital ecosystem in Estonia

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We discuss the core features of the Estonian digital ecosystem that have led to an exponential growth of in public digital service usage and started a move into the so-called post-digital society. A universal electronic identification system ensures that all citizens have default access to digital services. Uniform universal access is complemented with a distributed data exchange layer called X-Road, which allows service owners to engage in peer to peer data exchanges. Such a system has created positive dynamics from service demand (citizens) and supply (service owners) side. The secure digital identity enjoys high trust, which leads to high service usage rates and increased demand for more digitalized service. That same secure universal access and a data exchange system that is designed to create network effects, ensures a large immediate customer base for service owners, which makes data intensive digital service development faster and more cost-efficient. Finally, the frequent exchange of technologists between the private and public sector ensures rolling out of services and policies, like the e-residency program, that create new international customers for otherwise national digital services.

From digital to post-digital

Estonia, a tiny Northern European nation of 1.3 million people, is a consistent high performer in comparative measures of digitalization. OECD's Digital Government Index (DGI) 2023 ranks the country sixth globally in the overall index and second in the data driven governance and proactiveness of public services sub-indices [1]. The EU's Digital Economy and Society Index (DESI) shows Estonia consistently among the top countries in digitalization of the public sector services, ranked third in Europe in 2023 for digital public services for citizens as well as businesses [2] and the UN's E-government Development Index (EGDI) ranks it eight globally in 2022 [3].

The country has been suggested in the past to be the first to implement Tim O'Reilly's famous government-as-a-platform vision in reality [4] and is now trying hard to take the next big leap in public sector innovation through a comprehensive implementation of pro-active public sector services powered by machine learning and AI methods. This should move the country into a new post-digital stage. Such a new effort is needed as at an advanced level of digitalization, with 93% of internet users reporting to having used at least one e-government service in the past 12 months [5] and a reported 99% of public services available online [6], further process and service digitalization faces diminishing returns and no longer brings the desired efficiency and effectiveness gains.

A post-digital era proceeds from the recognition that digital is the default mode of public service delivery anyway and simple technology driven efficiency of services is therefore increasingly hard. The effectiveness of services in delivering the intended wider societal outcome, however, is now the central mission of governments [7]. This means a re-focus from running a public service system that delivers service outputs efficiently with the help of

technology, to an outcome-oriented technology intensive service design and management that sets the individual and societal value as the main goal.

Pro-active and personalized government

The post-digital realm means the individual citizen has a larger role in ensuring that the service actually delivers the societal value it is supposed to bring. How does this actually work? In the Estonian case this means scaling two digital service attributes to higher levels.

One is pro-activeness, which means the latent service need is detected and a service menu is pro-actively pushed to the citizens. The second is personalization, which means the service response is tailor made for the individual.

A combination of those two attributes should bring the intended service outcomes about more likely through three ways.

First, pro-activeness reduces any information asymmetries citizens still face in determining if they are eligible for certain services and cuts out the timely process of needing to "pull" a service response from a public sector body. It also allows a wider usage of digital self-service environments for more complicated services, like active labor market measures.

Second, personalization will more likely trigger an individual reaction of service outcome internalization, meaning a sense that this solution is designed for that individual directly. This is something that has been proven by research to lead more likely to motivational change and to the individual actively working towards actually attaining the outcome. In other words, it more likely leads them towards a desired behavior, transforms their motivation, manages a potential risk, or helps them seize and actualize an offered opportunity effectively.

Third, personalization will frequently involve a more complex service response that spans multiple agencies. This means the underlining issue, like losing a job for example, will be responded to with a bundle of social and labor market services from different service owning institutions, which in combination will address the root cause holistically and shorten the experienced unemployment spell.

Pro-activeness and personalization of public services are not new ideas, but doing this at scale has been extremely difficult and very few have attempted to set it at the centre of how their public services should be designed, delivered and governed [8]. Part of the problem are the organizational, legal and data dependencies such a service delivery model implies. Consequently, it also means such a goal can only be set when the core requirements, such as data availability, micro data linkability, data exchange infrastructure, joint service governance models and citizen trust in their data usage, are met.

We discuss below how some early state information system design decisions led to the creation of a digital ecosystem [9] which triggered organic growth of digital services and their uptake. This has matured the system to a level where public sector technology innovations can now be tested and deployed comparatively faster and cheaper, including thinking of how to transition to "post-digital" service delivery models. We'll outline the core elements of the ecosystem and explain the role those have played in further detail next.

Universal access: secure digital ID

An early core element of the system was and still is a secure electronic identification system (eID). This was introduced in 2002 in the form of a compulsory ID-card which could be used both as a physical as well as digital ID for authentication and digital signatures using public key infrastructure (PKI) [10]. Over time additional optional eID solutions, like a smartphone based Mobile-ID which uses a PKI enabled SIM card and Smart ID which is an app based

strong authentication and signing solution, have been introduced and are now pervasive. This means that the Estonian eID has practically 100% penetration, though not the whole population is actively using it as such at all times. This also means that any digital service provider, public or private, that needs secure client identification and possibly legally valid digital signatures in their interactions with clients, know that they can offer services through a digital-only channel accessible to the whole population and do not need to provide nor manage client authentications. This eID scheme was widened into a global solution through the e-residency program in 2014, which is in essence an Estonian state provided transnational digital identity scheme for foreigners who want use the Estonian digital infrastructure to run their business in the EU. As the Estonian eID system is compliant with the EU's electronic identification, authentication and trust services regulation, as well as with the payment services directive, it can be used to run a business remotely in the EU from outside of it. As of late 2023 more than 100 000 people have been issued Estonian e-residency [11] and companies established by them are paying taxes into the Estonian state coffers.

Infrastructure: service channels and data integration layer

Digital services accessible with the eID are mostly delivered through web portals or mobile platforms. There is a state portal that serves as a central platform that guides citizens to services, but these can also be accessed directly through the provider's portal.

The integration layer that allows various services to cross-use data is a distributed service bus named X-Road. In essence it is a network of access points that allows different data repositories to exchange data, mostly by way of APIs and provide service to various data consumers. Though the network access is managed centrally, the data exchange happens peer to peer. For example, the Population Registry, which holds individual address data, has a list of X-Road services for potential data consumers one of which is providing address data for any service that is location dependent (mostly local municipality digital services). The public digital service provider that needs address data then connects by agreement to that particular Population Registry service and starts to query the data over the X-Road to determine if the individual is eligible to receive it.

As of early 2024 approximately 790 private sector and 190 public sector organisations are connected to X-Road and they list more than 3300 separate services on the system. X-Road handles roughly 255 million service request queries a month and has handled 14 billion requests in total since its launch in 2001 [12].

The effect of this data integration layer on digital service development cannot be underestimated. First, it has drastically reduced costs of secure administrative and private sector data exchange. A service owner or data consumer can connect to the system either through self-service or through third parties providing a service of connecting to the X-Road with a fraction of the cost that they would have had to bear to establish their own peer to peer data exchanges. Second, it introduces much-desired network effects. The value of a X-Road linked data repository or data provision service increases with every new X-Road member or new digital service. The result has been an exponential growth in usage aptly demonstrated by the service request queries growing from 270 000 monthly queries in January 2004, to 31.5 million in January 2014 and 255 million in January 2024 [13]. Third, it eases the development of new services as the upfront costs of determining data availability and exchange possibilities fall away. Also, proof of concept studies and prototyping of applications become noticeably faster and cheaper.

Uptake: data usage and trust

Most digital services involve cross usage of data from different registries. A non-trivial factor enabling this is the ability to easily link citizen data across datasets, something that many countries are struggling with even for base registries. In the Estonian case this problem has been largely a non-issue as all residents are issued a unique personal identification code (PIC) which is also used as the primary key in databases. The ease of linking data with the PIC leads to higher cross- and secondary usage, but also introduces additional data misuse risks and might jeopardize public trust. Given that trust is one of the primary drivers of service uptake and usage additional trust building measures that help to make it more robust should ideally be implemented. One widely recognized measure to increase trust is to introduce more transparency into administrative data usage [14]. It is somewhat paradoxical that the same system that allows easy data linking and usage also allows better citizen oversight. In the Estonian case this is built into how the peer to peer data exchange happens on X-Road. A data request from party A by way of a X-Road service to a registry held by party B goes through a standardized security server of party B, which records all traffic in and out of that database. This record, which includes all requests on the subject made to party B, is made available to the subject i.e. the citizen through a simple interface on the state portal [15]. The person can log in using the eID and see who has queried his/her data. Any follow-up on the exact purpose of the query will have to be done by the citizen, but it gives the person an actual mean to exercise their right to know who is using their data for what purpose.

The result of a conscious effort to introduce more trust building measures is an overall high trust in digital services and the e-state solutions, with upwards of 80% trusting public e-services [16]. High trust means high uptake with 99.9% of prescriptions being digitally prescribed, 99% of income tax declarations being declared online and 51% of votes in the last national election being cast over the internet.

Trust also seems to be resilient, as security crises, notably the 2017 discovered ROCA vulnerability of ID-cards which required the renewal of 494,000 cards and remote update of 354,000 cards out of a total of 1.4 million active at that time, have not led to major drops in service usage [17]. The discovered cryptographic vulnerability in a widely used code library allowed to infer private keys from public keys. Though it had global implications for security of encryption keys generated by this, the Estonian ID-card was probably the most prominent system affected by it. The choice of the government at the time to make it public and handle the national crisis as openly as possible led to relatively quick and painless process of fixing the problem and no noticeable effects on digital service usage.

Spillover effects to and from technology sector

The three above-mentioned factors – universal access, distributed infrastructure, trust in data usage - have combined into an environment that is very conducive to technology entrepreneurship.

Together with the digitalization of public sector services an impetus was put on digital skill development of the population to lower thresholds for service uptake, part of it was also a special focus on IT education programmes. ICT graduates now make up 10.1% of all graduates, which is the highest share in Europe according to Eurostat [18]. The success of local technology companies and start-ups occurred in parallel with the digitalization drive and both processes have fed into each other. Estonia ranks first in Europe with 4.5 companies with a billion plus dollar valuation per million inhabitants in 2023, partially due to the so called “Skype effect” where former employees of the company, whose development and engineering took place in Estonia, have started more than 900 companies and are employing 65 000 people globally [19]. Part of the close cooperation between the public and private sector during the

digitalization drive involved technologists doing short private sector service turns, including some early skype alumni. This means the technologies and programs implement were both more in tune with ongoing tech market trends as well as better catered to entrepreneurial needs. The aforementioned e-residency for example does not offer simply a secure and accepted digital identity, but access to a set of services that allows establishing and running a company location independently. A separate startup visa program is targeted to non-EU founders to lure more talent to the country. The total value proposition is therefore not only a state-provided highly digitalized environment to ease business operations, but also informal access to other founders, tech entrepreneurs and VCs. And all this is finally amplified through a conscious effort of place branding and soft power projection to get the attention of international talent.

To sum up let's come back to Tim O'Reilly's and his government-as-a-platform idea. Among other things he also suggested to "build a simple system and let it evolve" [20]. The core elements of the Estonian digital ecosystem seem to have been copied from this suggestion : 1) ensure secure universal access to citizens through eID; 2) create a distributed system that allows everyone to talk to everyone's data, because you never know who comes up with good ideas and how network effects kick in; 3) build in trust measures to ensure citizens actually come on board as users.

Funding

This work was supported by the Horizon 2020 Framework Programme grant number 857622. The financing agency and authors' employers had no role in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication.

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