APIs in the public sector of EU Countries

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I would like to dedicate this thesis to my loving parents ...

Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other university. This dissertation is my own work and contains nothing which is the outcome of work done in collaboration with others, except as specified in the text and Acknowledgements. This dissertation contains fewer than 65,000 words including appendices, bibliography, footnotes, tables and equations and has fewer than 150 figures.

Michail Loukeris
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Abstract

New technological developments have strongly influenced the way we live our everyday lives, the way we perform daily activities such as shopping or communication. Every day, more and more people have access to the Internet and to newest technological tools which help them make their lives easier and of better quality. This is something that since the past twenty years Governments of different countries have tried to take advantage of, by applying all these new tools to their different functions in order to simplify their services, make them globally accessible and reduce the red tape and generally become more effective both internally as well as externally.

Countries such as Estonia, the UK, Singapore or Denmark have managed to migrate to a fully digital government where every operation such as tax paying, transportation and drive license issuing, employing people and more are done digitally.

This study provides an analysis of Web APIs as enablers for the digital transformation of government. While digital transformation of government is much wider than the technologies which can potentially support it, an analysis of the role of Web APIs in the public sector is highly relevant to illustrate how technology can enable the transformation of government. The aim of this work has been to identify the ability of Web APIs to assist Member States with enabling their digital transformation. Areas of specific focus include cross-border interoperability between Member States and the opportunity for the EU to become involved in developing or advocating API standards.

This research set out to explore the API landscape in the EU public sector. API is the acronym for Application Programming Interface and it refers to a set of clearly defined methods of communication between a service and any other software or components,essentially, a software intermediary that allows two applications to interact with each other. The purpose of the study has been to identify the ability of Web APIs (hereafter “APIs”) to assist Member States with enabling their digital transformation. Areas of specific focus include aspects such as cross-border interoperability between Member States, and the opportunity for the EU to become involved in developing or advocating API standards.

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Chapter 1

Introduction

At a policy level, the Tallinn Declaration, signed on 6th October 2017 [cite 2], confirms the commitment to the vision laid out in the EU eGovernment Action Plan 2016-2020 [cite 3] and in the European Interoperability Framework (EIF) [cite 4]. In the next five years (2018-2022), steps will be taken towards the declared principles in EU public administrations, namely: "digital-by-default, inclusiveness and accessibility", "once-only", "trustworthiness and security", "openness and transparency", and "interoperability by default", as well as national interoperability frameworks based on the European Interoperability Framework (EIF).

In the Declaration the "user-centricity principles for design and delivery of digital public services" is key. When interacting with public administrations and using digital public services, citizens and businesses should have: digital interaction, accessibility, security, availability and usability, reduction of the administrative burden, digital delivery of public services, citizen engagement, incentives for digital service use, protection of personal data and privacy, redress and complaint mechanisms. Whilst not specifically covered within the scope of this study, AI has the potential to improve public services and contribute to the objectives set out in the Tallinn Declaration. For example, the Commission will look into AI's potential to analyse large amounts of data and help check how single market rules are applied [cite 5].

Moreover, the digital transformation of society, business and government is raising issues for a range of policy matters across the European Union. As e-government has been in place for the last 20 years, it is timely to explore the interplay between technology and government activities from the perspective of digital government. To understand the intertwined forces that play a role in this transformation process, and their dynamics, contributions from disparate fields and discourses on this topic should be contrasted and compared.

At the same time, the Communication on "Building the data economy" (COM (2017) 9) looks at proven or potential blockages to the free movement of data and presents options to remove unjustified and or disproportionate data location restrictions in the EU. It also considers the barriers around access to, and transfer of, non-personal machine-generated data and data liability, as well as issues related to the portability of non-personal data, interoperability and standards. In particular, it calls for the fostering of technical solution development for the reliable identification and exchange of data.

A further avenue for research, complementary to this context of the digital transformation of government, is the use of Web Application Programming Interfaces (hereafter called "APIs")). APIs can be seen as "safe entry ports for new and innovative uses of data" held by companies and, potentially, public administrations.

An opportunity exists to understand the current context and uptake of this technology early in the innovation cycle of e-government in Europe, including for, but not limited to, geospatial data.

In this context, Gartner was mandated by the Joint Research Centre (JRC) to conduct a study to provide an analysis of the Web APIs as enablers for the digital transformation of governments. While digital transformation of government is much wider than th e technologies which can potentially support it, an analysis of the role of APIs in the public sector is highly relevant to illustrate how technology can enable transformation of government. This study explores APIs, and their role in the EU public sector.

1.1 Glossary

Term	Definition
API	Application Programming Interface - It is a set of clearly defined methods of communication between the service and any other software or components.
API Ecosystem	The developers, and the users of the application constructs they build through an API, either within a company or on the Internet with business partners, customers, citizens etc.
API Economy	A set of business models and channels — based on secure access of functionality and exchange of data to an ecosystem of developers and the users of the app constructs they build — through an API, either within a company or on the Internet with business partners, customers, citizens etc.
API Versioning	The ability to change without rendering older versions of the same API inoperable.
API Standardisation	A uniform way for APIs to be expressed and consumed, from COM and CORBA object brokers to web services to today's RESTful patterns.
API information control	A built-in means for enriching and handling the information embodied by the API. This information includes metadata, approaches to handling batches of records, and hooks for middleware platforms, message brokers, and service buses. It also defines how APIs communicate, route, and manipulate the information being exchanged.

API portal	A means for developers to discover, collaborate, consume, and publish APIs. To support the overall goal of self-service, these portals describe APIs in a way that represents their functionality, context (the business semantics of what they do, and how they do it), non-functional requirements (scalability, security, response times, volume limits, and resiliency dimensions of the service), versioning, and metrics tracking usage, feedback, and performance. For organizations without mature master data or architectural standards, the API portal can still offer visibility into existing APIs and provide contact information for individuals who can describe features, functions, and technical details of services.
API gateway	A mechanism that allows consumers to become authenticated and to "contract" with API specifications and policies that are built into the API itself. Gateways make it possible to decouple the "API proxy"—the node by which consumers logically interact with the service—from the underlying application for which the actual service is being implemented. The gateway layer may offer the means to load balance and throttle API usage.
API brokers	Enrichment, transformation, and validation services to manipulate information coming to/from APIs, as well as tools to embody business rule engines, workflow, and business process orchestration on top of underlying APIs.
API management and monitoring	A centralized and managed control level that provides monitoring, service level management, SDLC process integration, and role-based access management across all three layers above. It includes the ability to instrument and measure API usage, and even capabilities to price and bill charge-back based on API consumption—to internal, or potentially external, parties.

RESTful API	REST stands for "representational state transfer." APIs built according to REST architectural standards are stateless and offer a simpler alternative to some SOAP standards. For example, REST enables plain-text exchanges of data assets instead of using complex WSDL protocols. It also makes it possible to inherit security policies from an underlying transport mechanism. At a high level, these and other simplified approaches can deliver better performance and faster paths to develop, deploy, and triage.

Table 1.1 Glossary

1.2 API Overview

APIs have become a foundational technological component of modern digital architectures, impacting every sector of the global economy. In the public sector specifically, APIs are a key enabler of the accelerated evolution of government and its agencies from analogue (manual, paper) operations, to digital.

The purpose of our study is to create a report that will support member states with the adoption of APIs when in pursuit of their digital transformation. In order to explore this purpose, our investigation has incorporated (but is not limited to) the following topics:

- The current use of APIs in the EU public sector.
- Differences between API use in the public sector and the private sector.
- The future trends for APIs.
- The relationship with location data.
- Insights from eight case study interviews, using real world examples to explore different dimensions of the API landscape, including API Strategy, API Ecosystems, and specific APIs.

Our approach is covered in detail in the Methodology section later in this report. In summary, we have used a combination of desk based research and interviews to gather information for analysis. For the interviews, we used a questionnaire to collect information

from representatives of a set of successful but diverse API based case studies from a range of EU countries and sectors.

API Overview

API interaction occurs when one application would like to:

- Access or query the data held by another application.
- Send data to that application
- Update data held in that application
- Request a service from another application

Types of APIs Crucially, the use of APIs therefore simplifies, and standardises the interface reducing complexity and cost of deployment over that of custom built interfaces. APIs represent an architectural approach that revolves around providing programmable interfaces to different applications. It is technology agnostic, and creates a flexible, loosely coupled architecture that allows a solution to be made up of components that can more easily be switched in and out. The API approach is also a key enabler for application developers to build apps that rapidly adapt to end user needs [cite 6].

In the public sector, APIs enable important functionality and information held in one agency's system or department to be readily available to another without significant and expensive development effort. As well as cross-departmental (agency) access to functionality and information (or even cross-border with a different country's administration) APIs also provide the ability to share information and functionality more widely, i.e. to developers and ultimately to citizens for consumption through web or mobile based applications.

Although there are many different types of API (see Appendix I), this study is most concerned with Web APIs. Web services expose these APIs as endpoints that any internet-enabled language or software can access, in exactly the same way browsers access websites and services [cite 7]. Web APIs deliver requests to the service provider, and then deliver the response back to the requestor, i.e. they are an interface for web applications, or applications that need to connect to each other via the Internet to communicate [cite 8].

Web APIs themselves can be broken down further based on the type of data format that they harness, for example, well known types are Simple Object Access Protocol (SOAP), Remote Procedure Call (RPC) based APIs, and the Representational State Transfer (REST) architectural style. GraphQL – is a data query language growing in popularity and has been adopted by leading social media outlets such as Facebook and Pinterest [cite 9] as a type of API. While typical REST APIs require loading from multiple URLs, GraphQL APIs get all

the data an app developer needs in a single request enhancing speed of response even on slow mobile network connections [cite 10].

Whilst the more traditional APIs are used as integration points within systems hidden from view, Web APIs are often publicly available and can be 'advertised' via API Directory sites online. Tens of thousands [cite 11] are available for developers to deliver consumable information to end users to do everything, from checking traffic and weather, to updating a social media status, or even to make payments.

In the geospatial domain, besides existing private companies famous API proposals (e.g. Google Map), the Open Geospatial Consortium (OGC) has created standards to support the exchange of geospatial information [cite 12]. They describe their Web services API standards as an agreed specification of rules and guidelines about how to implement software interfaces and data encodings [cite 13]. Geospatial software vendors, developers and users collaborate in the OGC's consensus process to develop and agree on standards that enable information systems to exchange geospatial information and instructions for geoprocessing. OGC standards are open standards. The OGC interface standards are also available in the REST style, and cover a number of aspects:

- Visualisation standards e.g. Web Map Service (WMS).
- Data Access Standards e.g. Web Feature Service (WFS), SensorThings API.
- Processing Standards e.g. Web Processing Service (WPS).
- Metadata and Catalogue Service Standards e.g. Catalog Service for the Web (CWS).
- The informatics contract between the client code which manipulates normalized data structures of geographic information based on the published API and the library code, e.g. the GeoAPI Implementation Standard.

The standards above are part of the few globally agreed specifications adopted by the Technical Committee 211 of the International Organization for Standardization (ISO). ISO is also known to be working on standards in other sectors, notably in Financial Services with ISO 20022 [cite 14]: however, because of they are work in progress, details about them are still limited. Whilst standards of this formal and specific nature are used in the EU, there is clear evidence that the need for harmonising APIs lifecycle has been recognised. For example, the UK Government Digital Service recognised that departments were developing APIs using different tools, platforms and approaches [cite 15], and have set about working with industry to create a set of common principles for API design. The output has been a set of guidelines on how developers working in any UK public sector organisation should build APIs [cite 16]

to ensure consistency, and success. Although they are titled as a ‘standard’, they are generic, and not exact or specific in the way that an ISO or OGC standard is. Nevertheless, given the fact that government is increasingly using APIs to automate processes and provide citizens with access to new services it is hoped this approach will make integration simpler and faster.

Chapter 2

APIs in the Public Sector

The Internet, social media, smartphones, and access to real-time information have not only made people's daily lives easier, but have changed citizens' expectations of how products and services are delivered. In the public sector, this shift has raised the expectations of citizens and business in their interactions with government.

People are demanding transparency, accountability, access to information and competent service delivery from their governments. They also expect policies and services to be tailored to their needs and address their concerns.

In this section, we will explore how APIs are used in the public sector. We will firstly look at typical uses, such as the enablement of ecosystems, before looking at some specific examples of API use. In addition, we will cover some challenges and considerations, and examine data on the APIs advertised in one of the most respected API Directories, (ProgrammableWeb) as a further indicator of the way APIs are used in the public sector.

2.1 APIs enable the public sector to create 'ecosystems'

API based ecosystems can be defined as the extended interrelationships enabled by developers who create applications that link various groups of stakeholders to each other via API based solutions that use the internet to communicate [cite 18].

An ecosystem may be created within a government agency, between agencies, or it may be wider reaching, for example between a government and another government or between a government, their citizens, and potentially third party providers.

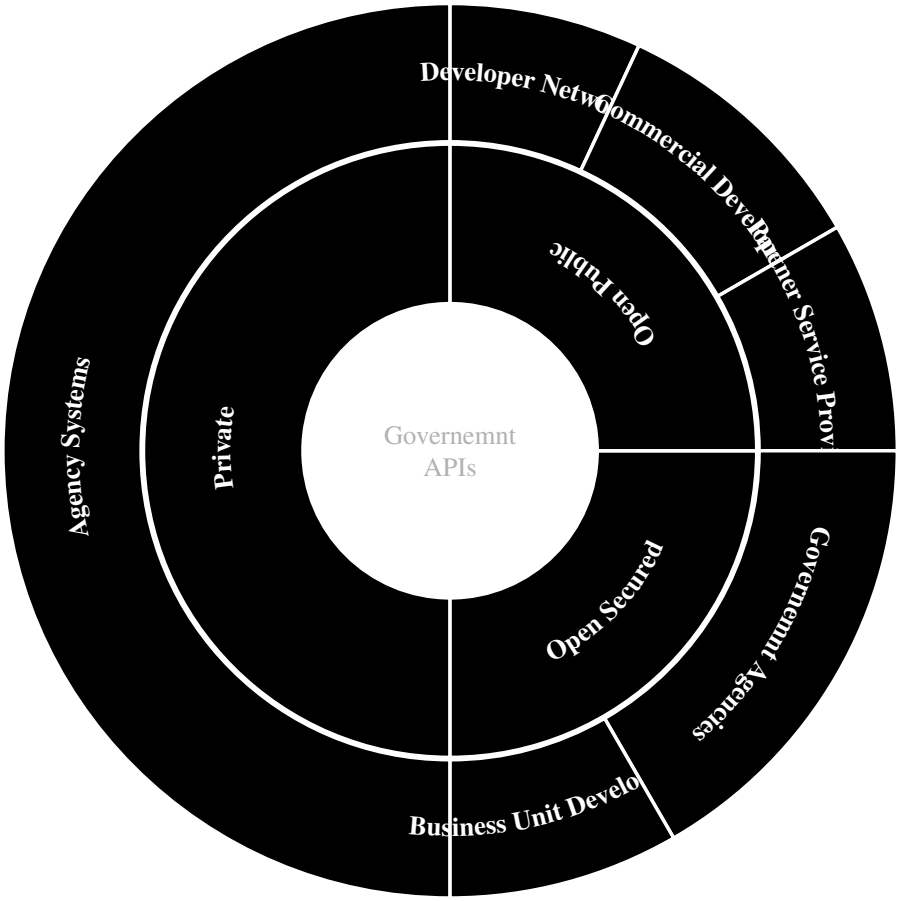

Fig. 2.1 Ecosystems enabled by government APIs

[cite 19]

The figure above illustrates the way in which APIs are used, and the typical ecosystem that they facilitate in the public sector.

- Private – Agency Systems: These APIs are generally used to facilitate the sharing of data between systems within an agency, avoiding the need for complex point to point integration. They are not visible to any person or body outside of the agency and are generally in the domain of the IT department. An example maybe a link between an internal HR system and a Payroll solution.

- Open Public – At Large Developer Networks: Open APIs (i.e. you do not require permission to access them) are the access point for developers to access large public data sources such as a census information or other similar statistical data, perhaps live sensor data from which to create citizen-facing applications.

- Open Public – Commercial Developers: As above, but developers who are looking to gather freely available data for use, generally, in applications that can be sold. They may add value by 'mashing' the data, i.e. combining data on public transportation networks with location data available on an individual's smart phone to help the citizen make travel choices in real-time... Because of this openness, third-party integration of software is not only easier but less problematic. Developers have access to the API at all times, so they can ensure that the two-way communication between assorted pieces of software is correct, rather than having to guess at the appropriate methods to use.

  It is also worth noting the economic stimulation that this can bring. Transport for London's policy of working with major IT players (Google, Apple, Waze etc.) but allowing their data to be available via the Open Government License has led to the creation of additional economic activity in the order of £100m of direct value and has enabled some 1,000 jobs [cite 20].

- Open Public/Secured – Partner Service Providers: The APIs are open to partners perhaps in the private sector which may include healthcare providers for example, who in some member states are interested in sharing healthcare records, or confirming eligibility for free or subsidized treatment based on data held by a government agency.

- Open Secured – Government Agencies: These APIs are available to other government agencies and allow them to share data only once they have authenticated. This supports many of the core tenets of digital government, allowing agencies to collect data on a citizen only once, and then share it securely. An example may involve the sharing of citizen data between say the agency responsible for income and taxation, and those

providing benefits in order that eligibility could be confirmed. Please see later case studies relating to Estonia X-Road, and Amsterdam City Data for more on this.

Although not specifically mentioned in the diagram above, the ability to use APIs is not constrained by sector or geographical boundaries. Open Secured – Government Agencies could include an application to application link between governments of different member states. A good example (explored further later) would be the Estonian X-Road Platform which uses APIs to share citizen's healthcare information with Finland.

- Open Secured – Business Unit Developers: Similar to the above, but instead of basic inter-agency data sharing, in this case the data is being consumed and then in some way supplemented in order to be useful by developers within a government agency. They are used to create custom applications around internal data assets for agency use.

In summary, the creation of an 'ecosystem' of providers and consumers fosters openness and efficiency, and can also spawn the development of innovative service models, some of which may lead to revenue generation for the agencies concerned (for example mapping data [cite 21], or gazetteer data). Their ability to provide access into the heart of government, in turn allows government to realise its objectives of openness, and of delivering efficient, secure, transparent and interoperable citizen centric services. The APIs are, therefore, a crucial technological component, which will underpin empowering the evolution of public service delivery models, enabling agencies to accelerate their transformation from eGovernment to Digital Government.

2.2 APIs enable public sector agencies to overcome complex integration

Nearly all EU countries have developed their computing infrastructure over many years, constructing a legacy of large, complex information systems featuring interfaces to pass information from one system to another. The majority of these interfaces were point to point and custom built to meet the needs of a particular project or agency at a point in time. As the number of interfaces grew, so did the maintenance burden; the inter-relationships and the data duplication leading to an expensive, complex and inefficient architecture [cite 22]. In summary, these "siloed", legacy government systems and associated business processes increase risk and exacerbate challenges in data sharing and service delivery across the ecosystem.

APIs provide an opportunity, in effect a structural 'workaround', to enable the information within these legacy systems to be exposed with comparably low complexity and investment. They can be plugged into legacy systems of record such as ERP systems [cite 23], or citizen facing records to make the data records directly available, thus helping to bypass the complex interfaces of existing systems, and allow data sharing to be accomplished more easily. This means that a well-designed government ecosystem could help minimise the frequency that citizens or businesses will have to provide the same information (Once Only Principle, OOP).

A good EU example of where API infrastructure is currently being used to overcome the restrictions of traditional integration solutions is Estonia's X-Road Platform. It allows citizens to provide common 'private and sensitive' information to public administrations only once, for example, marital status. The ecosystem also includes private institutions such as banks who can have access in order to perform various functions. X-Road is examined in more detail in the case studies section of this report.

EU Example: ESTONIA X-ROADS PLATFORM

"X-Road is the backbone of e-Estonia. Invisible yet crucial, it allows the nation's various public and private sector e-Service databases to link up and function in harmony." [cite 24]

X-Road is a government API framework developed by the Estonian government and licensed under the MIT license. It is also used as a backbone of the Finnish National Data Exchange Layer.Originally built for SOAP/XML web services, it now extends to REST APIs. Rather than requiring governments to develop API management directly, X-Road provides an API management layer, including an API gateway, which is open-sourced and available to governments worldwide. [cite 25]

The X-Road solution includes a security server to provide identity and access management for government API access. It also provides central monitoring of API traffic. In addition to the management of APIs, it also provides an aggregation layer in front of multiple databases. This facilitates the creation and delivery of data access APIs.

Since each government service/agency has its own databases they all use X-Road to securely communicate and share 'private and sensitive' data to protect the 'once only' principle of sharing data with government. The service also incorporates many other sectors numbering over 900 organisations and enterprises including those in the banking, health and utility sectors [cite 26]. Whilst they may use the platform to perform functions such as identity verification, powerful use cases such as automated extraction of funds from bank accounts for those failing to keep up to date with taxes are possible.

All that being said, the X-Road itself is a 'very low level engineered application' [cite 27]. Following certification, an organisation deploys an x-road gateway so that it can hold secure private communications via APIs with other certified organisations that are legally able to

share data with it. As a collective toolset, the e-Estonia services provide the government of Estonia and its partners, including Finland, with a platform on which to innovate and use digital transformation to deliver new services across the globe.

2.3 APIs support the public sector open government initiatives

Open Government can be defined as the opening up of government processes, proceedings, documents and data for public scrutiny and involvement, and is now considered as a fundamental element of a democratic society [cite 28]. The Open government initiative started in 2009 by Barak Obama [cite 29], after that, numerous governments adopted open data initiatives. It is founded on the belief that greater transparency and public participation can not only lead to better policies and services, they can also promote public sector integrity, which is essential to regaining the trust of citizens in the neutrality and reliability of public administrations.

APIs have become synonymous with facilitating the opening of large data sources to citizens and other third parties. The Open Government imperatives have meant that API technology has been exploited outside of the 'IT department', providing access into large open data stores so that developers and their applications and websites can more easily consume it. When a government agency publishes an API for their data set, they open up new and innovative ways to access the data. A developer might create a mobile or web app to display the data intuitively or allow simple queries or automatically generate charts.

The most relevant public sector that expose government datasets is The European Data Portal [cite 30] (EDP).

EU Example: European Data Portal (EDP)

The EDP provides access to 79 different catalogues, most with tens of thousands of open datasets provided my member state governments. The same site also provides access to over 300 use cases (services or applications) that have been developed using the open data sets available. Some of these applications have been created using APIs to query the EDP.

The access to the Portal is provided by a machine-readable API which enables its users to search, create, modify and delete metadata on the portal.31 APIs are available both via the Comprehensive Knowledge Archive Network (CKAN) [cite 32] and SPARQL [cite 33] endpoints.

2.4 APIs enable the public sector to innovate

APIs enable new innovative service models which better engage citizens and allow for more efficient delivery of their services. These services no longer have to be provided directly by the agency, partners and citizen developers can use available data to enable new solutions. Smart Cities and the vast amount of data produced by sensors supports the development of dynamic platforms and ecosystems providing contextualized, real-time location-based data from IoT or crowdsourcing to business partners and startups giving them opportunities to create new services or improve existing ones.

Transport for London have delivered successful innovation based on API use. Although other more innovative services are coming of age in areas such as Smart Cities, this example is one of concrete success in enhancing efficiency and citizen service delivery.

EU Example: TRANSPORT FOR LONDON (TfL)

At recent European conference34, Transport for London detailed the investment that that they had made:

- 200 data elements are made available through an API to some 12,000 developers producing some 600 apps that 40% of Londoners use.
- TfL has formed partnerships with major IT players such as Apple (for mobile payment, rental ofbikes), Twitter (for pushing alerts out), a two-way data-sharing agreement with Waze (enriching the app with data from the road network that TfL manages while benefiting from data collected through Waze) and Google (enriching the maps application with real-time data).
- The data can be consumed under the terms of the UK Open Government Licence with some minimal additions for free. This is done under a statutory requirement as part of UK legislation.Mechanisms are in place to ensure that consumption remains at an acceptable level. There is one single set of data at the base that are both consumed by TfL for its purposes and by third party developers. Developers must give attribution to TfL for the fact that their app includes TfL data.
- In terms of creation of additional economic activity, it has been calculated that this policy generates GBP 100m of direct value and has enabled some 1,000 jobs.
- For data acquired by a third party, e.g. Waze data, restrictions resulting from the partnership agreement apply.
- All data made available is data that TfL collects anyway for its own purposes. TfL is not collecting additional data merely to make available to third parties.

- Mashing data provided by TfL with privately-held data can bring additional insights (e.g. "Are there correlations between rainfall and collisions involving cyclists?").

2.5 Challenges and Considerations

For the most part, externally facing public sector APIs involve the movement of data that is sensitive as it often, in some way, refers to information about a citizen. This poses a number of consistent challenges for government:

- Security – APIs expose data, services, and transactions in order to build new services. This inherently increases the permeability of an organisation's network, which can expose new vulnerabilities for exploitation. Therefore, APIs must be appropriately secured to ensure data privacy and to ensure citizen confidence in the service delivery channel. APIs intended for access to public data must be protected from inappropriate use or abuse such as denial of service. A number of security solutions exist such as OAuth and Certificate based authentication, which are used in conjunction with a wider cyber security strategy and cryptography.

- Regulation – APIs play a significant role in the facilitation of government transparency. A recent EU ruling [cite 35] makes providing transparency into all IT services that will be used in technology projects a condition for receiving government funding, and it is more than likely that APIs are the core technology required to support the transparency principle.

- Further regulatory considerations which must be adhered to when sharing data through any type of interface are the General Data Privacy Regulation [cite 36] (GDPR), the Payment Services Directive (PSD2) [cite 37] and the Public Sector Information Directive (PSI) [cite 38].

- Specifications or Standards - Standards for APIs are available in small pockets such as the OGC [cite 39] standard, and the developing ISO standard in Financial Services [cite 40]. However, many organisations are developing APIs based on an agreed internal specification or style guide to promote consistency, rather than what might normally be recognised as a de facto 'standard'. Each API comes with detailed documentation for consumers which provides clarity on the type of API (RESTful, GRAPHQL, GRPC etc.). There appears to be limited appetite for further standard development in the aftermath of 'Open Government' which is different to the impact 'Open Banking' has

had in the EU which precipitated the agreement of an API standard (in the UK initially at least) [cite 41].

The work conducted by the FIWARE Foundation (Future Internet Ware) tries to overcome some of the challenges listed above. FIWARE will be analysed later in the document, but in summary it is funded by a combination of EU, corporate membership and venture capital funding and has created a scalable open source platform used to access and manage heterogeneous context information through open APIs [cite 42]. A standard for exchange of context information: FIWARE-NGSI (Next Generation Service Interface) is an open standard API to be used for Smart Cities, Smart Industry and Smart Agrifood [cite 43]. The EU has noted its success to date, however, its success in landing a standardized API that is universally used will be known only in time.

- Business Models – In the public sector, generating income from the provision of data that is publically owned, and is being used for the public good, has not led to the charging of users who wish to consume or query this type of data. Examples of charging mechanisms being in place are limited, one being the UK's Ordnance Survey maps [cite 44], and KLIP (one of the case studies explored later in the Section dedicated to the case studies) which charges map requestors to have a digital map of utility services generated for a specific location.

2.6 Quantitative assessment of API use in the public sector

It is hard to realistically quantify the number of public sector organisations that are using APIs internally, but the total amount across all enterprises and organisations is likely to run into the millions [cite 45]. Organisations that create outwardly facing APIs to enable interaction with large data sources are common globally. We know that they are common globally because of the number of APIs now registered with API directories – the name given to the many searchable catalogues of Web APIs available on the internet. In order to ensure that APIs attract the maximum amount of developers to leverage the data being exposed, organisations will publish their API with high-level technical specification. Therefore, conducting an analysis of a well-recognised directory is likely provide indicative information regarding the number of EU public sector APIs, and the sectors and associated public services that they support.

ProgrammableWeb [cite 46] is the best known and globally recognized API directory. Nordic APIs [cite 47] comments that it is 'exhaustive' and 'comprehensive', and is hand curated and searchable. Therefore, as one method of obtaining quantitative, data led insight, this study undertook a basic analysis of the almost 20,000 listed APIs (as at February 2018).

We selected the 'Government' category which reduced the number searched to 787. After initial high-level analysis, our findings were that only 110 of the 787 Government category APIs advertised on the directory originated from the EU. This may well be because of the US-based nature of ProgrammableWeb. The initial breakdown suggested that the majority of the registered APIs were at the National level:

TABLE

Most of the APIs provide access to open data sources for developers to use in order to create applications for commercial sale. Others have more democracy/citizenship based aims.

2.7 Conclusion

APIs enable cost effective data sharing through both private and public ecosystems, which is in turn leveraged by developers to generate benefits for the citizen, for business and for the economy. The number of APIs is continuing to grow year on year (as demonstrated by the numbers recorded by ProgrammableWeb) is testament to the value that they provide for the public sector across a variety of use cases.

Chapter 3

Differences with the Private Sector

In this section of the study we will explore the differences between how the private sector exploit APIs, and how the public sector also exploits them.

3.1 API availability

Although it is hard to quantify the number of APIs that are in existence due to many of them being internal unadvertised APIs, externally available APIs are to some degree tracked by API directories such as ProgrammableWeb [cite 56], or RapidAPIs [cite 57]. A recent survey by Deloitte [cite 58] indicates that the public sector may have slower growth than the private sector which is also deemed to be slowing, or maturing. According to Deloitte, across global markets, public-sector API adoption lags and they suggest that this may be due to ongoing Open Government guidelines that mandate longer time frames for organising and executing largerscale API transformation initiatives [cite 59]. However, as explored earlier in this paper, a huge amount of government data is being made available for exploitation by citizen developers and commercial developers alike.

3.2 Business Models and Disruption

APIs have great transformative powers to disrupt business, when coupled with other technologies such as the powerful forces of Mobile and Cloud. The API is integral to the digital disruption in the commercial space, especially in retail, entertainment and social media [cite 60]– probably to a far greater extent than government has been disrupted today. Some of the world's biggest brands have been significantly disrupted, or taken out of business

by a new breed of companies that leverage technology to open up different ways of providing much sought-after services.

- The impact that Netflix had on Blockbuster made possible by Netflix's internal API, which handles two billion requests a day, and enables Netflix to develop and package new services for different platforms at speed.
- Amazon has required that all data-based communication between departments be done via API, naturally positioning Amazon to lead disruption in a world where APIs are becoming more and more ubiquitous. Amazon's disruption of the book industry was closely followed by providing access to their cloud via APIs creating a new business now worth 50bn.
- Dun and Bradstreet (D and B) as another example of APIs disrupting traditional business. The long established credit approval company has innovated with their API, enabling Dand B lookups to be performed from within third-party apps, or within SaaS services such as SalesForce.com leveraged APIs, creating a new revenue channel and disrupting the industry.
- First Utility, have demonstrated that APIs having destructive potential to alter the electric utility industry within the UK. They help users easily switch utility providers, aided by an API that enables customers to receive quotes and sign up for their service. In this way, their API is disrupting a whole industry.

The disruption of government may be driven by the ease in which private sector, or even third sector providers can integrate with government platforms via APIs to share and use data to drive new and improved service delivery models. Gartner's series of recent papers on the state of government in 2030 predicts that governments will relinquish service delivery by empowering the ecosystem, through intelligence and innovation, to improve citizen services. Architectures will become modular and flexible so that they can be agile and responsive to changing demands from the ecosystem. Thus, differences with the private sector use of APIs will converge.

3.3 Making money from APIs

APIs are an increasingly important part of revenue generating activities for business. In a recent survey of IT decision makers, Mulesoft, recently acquired by Salesforce [cite 61], a vendor of integration software found that 50% of large enterprises (10,000+ employees)

surveyed were making more than $10 million a year from API initiatives [cite 62]. In the public sector, generating income from the provision of data that is publically owned, and is being used for the public good, has rarely attracted fees. Examples of charging mechanisms being in place are limited, one being the UK's Ordnance Survey maps , and KLIP (one of the case studies explored later in the section dedicated to the case studies) which charges map requestors to have a digital map of utility services generated for a specific location.

Governments may need to become more financially driven/savvy as cost pressures become significant, and may choose to adapt to make revenue streams from ecosystems. This may manifest itself in a cost per API call model where, for example, transport data is being used by developers to create commercial applications. However, it is more likely to be part of a service delivery ecosystem with the private sector that provides efficiency and cost saving. For example, cities and local governments are predicted to collaborate with the automotive, insurance and health sectors to create ecosystems powering applications that deliver innovative solutions.

3.4 Conclusion

To date, government has harnessed the power of the API to make data more open and available to their citizens, and to themselves. The benefits range from increasing transparency, to enhanced efficiency of the existing service models. The private sector has harnessed APIs for a more transformative and disruptive end, giving rise to completely different business models, such as those which have made Netflix and Amazon great. The next section will deal with what the public sector may do in the future to disrupt itself in the face of increasing citizen demand, and cost pressures.

Chapter 4

The future trends for API use in the Public Sector

In this section, we will identify current thinking on how the use of APIs may evolve over the next 3 to 5 years. • Growth Rate - There is some evidence that the growth of APIs has slowed to some degree63. However, although the number of APIs may not be growing at the rate that was predicted a few years ago, their use and the ecosystems that they support continue to thrive. • Digital Government Platform growth requires APIs - Predictions on the future trends in Digital Government from research companies such Forrester and Gartner indicate that Digital Government Platforms (interoperable, horizontal microservices that are orchestrated by RPA (Robotic Process Automation) software will become more prevalent in the 3-5 year window64. Digital Government Platforms require APIs as the integration mechanism to move data between component systems and therefore governments will continue to invest in switching from a service-oriented architecture (SOA) to a modular architecture (MASA) utilising APIs and micro-services. • Government will invest in Intelligent Things requiring APIs – It is likely that governments will continue to increase investments in intelligent things, across many domains — from defence, policing, waste management, health, agriculture and smart communities65 to enhance service delivery quality, and efficiency. Sensor and video networks, intelligent drones, fleets of automated vehicles, and robotic devices will become core to government service delivery capability and serve as a real-time data source for government, using APIs to transfer data among IT systems and layers. It is anticipated that the next progression will see the environment composed of many physical things with both sensor and computation capabilities, which make the technology direction pervasive and invisible66. Applications will be capable of communication, cooperation, and negotiation with each other. Unlike general applications, agents will be designed with goals to be fulfilled on behalf of its users. That is, agents

will take necessary actions efficiently towards its environment over the P2P protocol. For example, an agent can be designed to read a patient's biometrics from a patients wearable sensor devices and adjust thermostats to heat or cool a patient's room appropriately. In this way, the new platform is not limited to a certain set of devices, and it opens many possibilities over the P2P protocol to produce novel (multi-Agent) applications that enrich the idea of ubiquitous computing67. • APIs as products – APIs are products, and as such should have a product lifecycle from conception and improvement through to retirement. Government IT departments will continue to move away from APIs just being a technology to implement and forget. Given growing ecosystems dependent on APIs, communicating to third-parties, monitoring usage, and removing at an acceptable time (i.e. versioning) will be important. • API Standards – The cost savings that can be realised by not having to redesign an API due to its 'drag and drop' portability seem compelling. The ability for applications and data sources to be able to link without the need for a bespoke API takes us one step closer to the ubiquitous platform of unbounded data. However, for many, knowing the specification of an API, and then getting to know the specific nuances of the API via the developer portal of an API provider seems to be a necessary, and perhaps keeps the developer community in work. • Citizen developers and Open APIs - Open APIs make it very easy for citizens to make use of open data, or improve existing applications which leverage it. Hackathons will become more widespread as a way for the public sector to engage with citizens, helping member states to meet the aims that they have of conducting significant user research prior to releasing any citizen facing services or data68 changes could potentially come faster than if we were to wait for the vendor to implement them. This process is very similar to open-source software, which is widely used and very helpful for developers.

4.1 Conclusion

The future of digital government seems deeply linked to the use of the APIs as enablers. As the technological demands of digital government move forward, it appears that APIs are well positioned to keep pace, and provide the access points needed to enable fast and secure data sharing to support government's needs from law and order, to healthcare and the environment. As with all aspects of technology, the use and development of APIs will evolve over time.

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Appendix A

API Types

API Type	Data Formats	Description
Web APIs	SOAP over HTTP/S	SOAP is a protocol that defines the communication method, and the structure of the messages. The data transfer format is XML. A SOAP service publishes a definition of its interface in a machine-readable document, using WSDL – Web Services Definition Language.
	XML-RPC over HTTP/S	XML-RPC is an older protocol than SOAP. It uses a specific XML format for data transfer, whereas SOAP allows a proprietary XML format. An XMLRPC call tends to be much simpler, and to use less bandwidth, than a SOAP call.
	JSON- RPC over HTTP/S	JSON-RPC is similar to XML-RPC, but uses JSON instead of XML for data transfer.

	REST over HTTP/S	REST is not a protocol, but rather a set of architectural principles. Some of the characteristics required of a REST service include simplicity of interfaces, identification of resources within the request, and the ability to manipulate the resources via the interface. The most commonly-used data format is JSON or XML. Often the service will offer a choice, and the client can request one or the other by including "json" or "xml" in the URL path or in a URL parameter. In a well-defined REST service, there is no tight coupling between the REST interface and the underlying architecture of the service. This is often cited as the main advantage of REST over RPC (Remote Procedure Call) architectures.
	GraphQL	GraphQL is a data query language developed internally by Facebook in 2012 before being publicly released in 2015. It provides an alternative to REST and ad-hoc webservice architectures. While typical REST APIs require loading from multiple URLs, GraphQL APIs get all the data an app developer needs in a single request enhancing speed of response even on slow mobile network connections.
Library based APIs	JavaScript APIs, TWAIN, Twilio	To use this type of API, an application will reference or import a library of code or of binary functions, and use the functions/routines from that library to perform actions and exchange information.

Class-based APIs (object oriented) – a special type of library based API	Java API	These APIs provide data and functionality organised around classes, as defined in objectoriented languages. Each class offers a discrete set of information and associated behaviours, often corresponding to a human understanding of a concept.
Object remoting APIs	CORBA	These APIs use a remoting protocol, such as CORBA – Common Object Request Broker Architecture. Such an API works by implementing local proxy objects to represent the remote objects, and interacting with the local object. The same interaction is then duplicated on the remote object,via the protocol.