Towards my.Government, an ACPaaS Digital eXperience Platform: Leveraging Micro-Services, Context, and AI to Optimise User Centricity

Abstract

Imagine that you work or live in a "smart" city, in an urban environment which is "sensitive" and virtually omniscient and in which you use and experience smart services on a daily basis. How do you picture this? At present users mainly interact consciously by means of their primary available digital interfaces: their laptops, tablets and smartphones. Soon this interaction will be far less intentional and intrusive and will blend inconspicuously into the lives, work, conduct and behaviour of citizens, visitors, commuters and workers. However, even the slightest elementary, but intuitive digital experience requires a vast and consistent battery of connected and intelligent systems. With ACPaaS or the Antwerp City Platform as a Service the backbone is already in place. By creating an Antwerp Digital eXperience Platform or DXP Digipolis intends to deliver the prerequisite building blocks for the aspired seamless and intelligent user interaction. Developers will be able to tap into a growing set of ACPaaS services and capabilities to create and power their apps or other digital interfaces. Additionally, information about people, organisations, places, objects, etc. will be available on the platform. Contextual information will qualify the behaviour of and/or the content displayed on the user interface. Bots and digital assistants are bound to increase the usability of apps, whereas artificial intelligence will make them smart and predictive. Additionally, the DXP will provide reusable assets comprising the base components of the user interface. Applied consistently, it increases familiarity and makes it more intuitive whilst strengthening the city brand.

1. Introduction

Digipolis is the joint IT-organisation and the dedicated ICT-partner of the cities of Antwerp and Ghent in Belgium. It is a governmental, non-profit, ICT organisation, established by the two City Councils, together with the Centres for Social Welfare of both cities.

In 2003 the IT-departments of these organisations were joined into one legal entity in line with the Flemish intercommunal law. In later years other subsidiary organisations of the members, like the department for elderly care, the educational department, the child care department and the city's urban development organisation, have joined Digipolis.

Digipolis has been the ICT-partner of the City of Antwerp for many years, collaborating on various ICT projects. Antwerp, a Belgian city with more than 500.000 people, has a clear city strategy: Driven by the need to better adapt the city communication and services to the needs, interests, and behaviour of its users (citizens, visitors, civil servants, businesses and other organisations), the City of Antwerp articulated an ambition in 2013 (College van Burgemeester en Schepenen Antwerpen 2013): "Each user should have easy digital access to the city services, in the most personalised and relevant way - to get informed, to apply for services, to get inspired or to get in conversation - where, when, and how he/she desires."

Digipolis facilitates and supports the city's end-to-end IT-solutions and is consequently a valuable partner in developing and validating new applications within a larger scale urban environment. Digipolis is an agile organisation with osmotic boundaries, an organisation that likes to pioneer and loves to be challenged.

One of the challenges is how to merge a city-wide constellation of apps and websites with specific purposes in a way it makes sense to a user for his/her tasks at hand. How should the city offer public services in a personalised way to each and every end-user at any given digital touch point? How could one enable this for any public service in a reasonable timeframe?

Within the city of Antwerp, the City Platform (Digipolis Antwerpen 2017) answers these questions. A set of reusable components, so-called engines, developed by start-ups, endlessly reusable, replaceable, open, and accessible for everyone who would like to develop software for the city.

Digipolis' next step is integrating artificial intelligence into the core of the City Platform and to infuse all imaginable applications, websites, any digital touchpoint within the city with artificial intelligence based upon personal context, historical and real-time. By leveraging AI, the end-user will have the feeling the city knows and understands him/her utterly. Even more, they will have a personal assistant guiding them and taking over several tasks. To enable this personal experience, a state-of-the-art Digital eXperience Platform containing necessary building blocks needs to be built.

2. ACPaaS: A City Platform Enabling Ten Times More

For several years Digipolis builds future-proof technology platforms, ready for any (digital) initiative, even beyond today's imagination. These prescient projects originate in the fact that the traditional way of working did not keep up with expectations to go "ten times faster, ten times cheaper, and ten times more innovative".

As was conventional in recent software development, Digipolis used to build or buy vast monolithic systems supporting the city's business processes. If these monoliths provided them with an undeniable sense of comfort, security and control, but they were equally unwieldy systems, even less agile, and largely burdensome to evolve into a next generation application. Often this type of software had a closed nature. Of course there are (or were) a number of good reasons to use this type of architecture. Most importantly, it is much easier to keep software and its management under control. Inevitably this leads to vendor lock-in and solidifies the privileged position of the software vendors in selling additional modules or licenses. Additionally, it raises problems in other situations. Monolithic systems are designed to be closed and, even worse, the collected data are virtually unfit for reuse, like for example for the construction of a much-needed reference context based on the user's individual preferences. In the view that data is the new gold, it is unacceptable to leave this goldmine unexploited.

IT consumerisation and the rising expectations of end users to be able to experience an efficient and modern working environment or a smooth public service offering calls for a radically new approach to application development. In pursuing this need Digipolis' system architectures shifted eminently towards a focus on reusability. Both the reusability of data and of the services itselves gained importance. While this evolution seems quite logical now, reusability was often lacking in the past. Data sharing amongst and across services, sharing generic services ensuring reuse by anyone and by all applications became crucial.

Following these principles, Digipolis started with the development of ACPaaS, the Antwerp City Platform as a Service (Digipolis Antwerpen 2017). The platform consists of a number of engines. Each engine provides a set of functions and/or services covering a given domain or functionality. Not only are the engines fully recyclable; each separate component is upgradeable on its own. Any service or dataset is reusable, ranging from the internal applications to the public toolsets for citizens and enterprises. If or when something, like personal notifications through a brand new social media channel for example, is not yet available in an operational engine, the extra service will be added in a next version.

Consequently the additional feature is automatically available for every application, app or website using the engine, and this without additional development nor investment.

3. Buy from Start-ups: Shift in Procurement Strategy of Innovative Solutions

Parallel to the development of ACPaaS, Digipolis took steps towards setting up a community of start-ups. The base of the community is the DigAnt Café group on the social networking site Meetup.com. It brings together the public and private sector, academics, and all types of enthusiasts such as students and hobbyists, and is used as a platform for knowledge sharing, networking, and gaining inspiration. However, the community is equally aimed at attracting and identifying small-scale creative entrepreneurs who can help to solve the Digipolis "challenges" in building "the digital city".

Prior to 2015 Digipolis did not work with start-ups for system development. The start of ACPaaS was an important facilitator to a number of changes in the Digipolis procurement strategy. Software purchases were downsized, away from the large-scale, monolithic solutions as much as possible. Reusable components, able to integrate into larger collaborative pieces of software, became the norm. Purchases were redubbed as exciting "challenges" rather than solutions, a key concept in the new Digipolis procurement strategy.

This approach, together with the accessible nature of the new procurement procedures (all unnecessary paperwork skipped) and the low throughput time of the process allowed Digipolis to become an attractive partner of the Antwerp start-up community very rapidly. Besides the realisation of a number of efficiency gains, another more important outcome was the organisational culture shift away from a closed, self-centered point of view. The influx of start-ups provided Digipolis with a range of innovative ideas and increased the number of purchased innovative solutions immediately. Today, Digipolis is contracting small-scale innovative companies, sometimes even before they are founded whilst negotiating, to build the applications and websites reusing or expanding engines on ACPaaS.

4. Our Guiding Star: Enterprise Architecture

To keep up with an open and fast-moving architecture, Digipolis defined a set of easily manageable but binding principles safeguarding the development of a future proof smart city software architecture. It is crucial that these EA principles are respected at all times to guarantee the reusability, the agility, and the innovative nature of the system. Currently these principles are:

1. Reusable APIs - All interaction is to be supported by reusable APIs. New APIs may be built but only with the intention of reuse. Accordingly, in order to ensure an open plug-and-play platform architecture, when building new services, microservices will be used by default.
2. Disconnected front and back - To distinguish their different goals any front-end is to be disconnected from the back-end. The front-ends provide modern and adaptive services. The back-ends focus on the reusability, business functionalities and APIs.
3. Hybrid modelling - Subsequent step-by-step migrations towards new technologies and business-features are to be enabled without big bangs.
4. Data centered - Three data classifications are to be considered:
   a. Locally used datasets
   b. Data sets shared with other city departments or public governments
   c. Central reference data: the sole source of truth for information on individuals and businesses, such as names, street names, house numbers, and many more

This approach created a whole range of opportunities to experiment with artificial intelligence at a governmental level.

5. Artificial Intelligence as the Cornerstone

Digipolis' AI activities are predominantly centred around four key elements, namely chatbots, natural language processing (NLP), image recognition, and (real-time) IoT pipelines. At this point in time these four components are in various stages of maturity, ranging from a proof of concept (POC) stage to a full ACPaaS-core reusable engine stage.

The most significant progress has been achieved in the application of the chatbot technology. The fact that the cloud solutions which dominate the current chatbot landscape did not fully meet the Digipolis requirements resulted in the development of a working and reusable ACPaaS engine. Shortcomings in the field of machine learning and DXP were the two major hurdles. Firstly, at the core of each chatbot engine there is an NLP model in place. However, taking a closer look at the existing cloud solutions it appeared that NLP models, comprised of the typical black-boxes, ruled out any subsequent software modification. In addition, there are only a very limited number of chatbots available supporting good quality Dutch, let alone any of its commonly used linguistic versions, being the predominant mother tongue and working language in the City of Antwerp. Secondly, ACPaaS requires its engines to accommodate modular and open (micro)-services, which is frequently lacking in the ready for use cloud solutions. This is in contrast to the Digipolis ACPaaS chatbot engine which does allow for any type of integration, and hence paving the path for a successful inclusion of the chatbot engine in DXP.

With modularity - being another ACPaaS key principle - in mind, the decoupling of the NLP logic from the chatbot engine itself into a separate NLP engine is greatly recommended. Digipolis' NLP research is ongoing and is prone to evolve into the development of an ACPaaS NLP engine shortly. A current first case investigates the ability of NLP and data science in match CVs (resumes) with job offerings. Traditional approaches using bag of words, TF-IDF vector space model, and cosine similarity (Jurafsky and Martin 2009) have already proven to yield very promising results. Lately NLP research has shifted towards the implementation of deep learning, and more specific the use of siamese recurrent neural networks (Bromley et al. 1993; Mueller and Thyagarajan 2016) to address the CV - job offer matching problem. With the development of an NLP engine, enabling the easy deployment of (deep) NLP models for various text-based applications, the step towards speech-based applications is merely an add-on, reusing again the same base architecture.

Next to NLP deep learning techniques are equally popular in image recognition applications. At this point, the Digipolis' image recognition research is still in a proof of concept mode. Two cases are being investigated: waste classification and automatic number plate recognition (ANPR). In the former case a classification convolutional neural network (CNN) (Lecun et al. 1998), based on Google's Inception model (Szegedy et al. 2016), is being created by means of transfer learning. In the latter, a multi-stage CNN for automatic multi-digit recognition (Goodfellow et al. 2014; Stark et al. 2015) is created. A first stage uses object detection to identify a number plate, while the second stage deploys a CNN for automatic multi-digit recognition. As cases for image recognition are nowadays widespread within an urban environment, the creation of a generic and modular image recognition engine is on the roadmap.

Real-time IoT pipelines is a final AI subject Digipolis would like to explore in-depth. Investigating this topic will have two major contributions to the DXP. Firstly, a variety of IoT devices which are already in place are apt to provide useful contextual information and will enable us to leverage the creation of a user centric platform. Secondly, IoT analytics will allow to experiment ardently with real-time pipelines. A number of cases in which data are being

collected and visualised in real-time have already been deployed in production. Although the mere visualisation of data does not require AI per se, research and development activities in real-time pipelines is more than defensible: Including image recognition techniques in the Digipolis architecture is expected to yield a breakthrough in the analysis of real-time video streams and footage.

6. DXP: The Next Step

In 2018 Digipolis aspires to combine aforementioned running initiatives and sets out with the implementation of a genuine DXP-strategy towards the creation of a state-of-the-art Digital eXperience Platform. This platform will be based on ACPaaS and will be fully customisable, in the sense of not only focusing on its user-centricity. The goal is to deliver a set of building blocks usable for any application as to guarantee a mind-blowing user experience, both within a single app and across multiple applications.

Three major DXP modules will be part of this project: my.Platform, my.Context, and my.AI.

6.1 My.Platform

My.Platform is a software architecture implementation applying contextual information and AI to offer the user in an intuitive way the adequate tools, for example, apps, for the execution of requests or actions. Such a harmonious and seamless experience of the platform's services is enabled by means of the continuous refinement of the acquired user and business context. The implementation is derived from the Digipolis EA principles and will therefore be able to deliver a multitude of formats and services like apps, websites, chatbots, etc. If developed properly, the user's experience of the platform's services should be smooth at all times, and this despite the modular architecture in which multiple apps and countless underlying microservices are interacting, and should never lead to fragmentation or confusion, nor overload. To this purpose user context, AI, dedicated UI elements, like for example a central dock and widgets, look and feel, and interlinking between apps are used. These elements will make sure loosely coupled components are presented as a whole. The Digipolis DXP platform pattern will be dynamic and extensible in order to anticipate evolving business requirements, and will have the ability of combining swiftly the relevant new features or applications. Moreover, the platform will have an infinite number of extension points for this integration or will migrate towards a self-generating front, based on the user's personal context.

6.2 My.Context

To be able to create a dynamic user centric my.Platform sufficient information of a current and historical personal context needs to be available. In my.Context data is collected from a varied number of sources. The my.Platform context will provide both historical and real-time data on usage. On top of this, the personal context collects all relevant data of the individual user within the borders of GDPR and privacy regulations. A real-time context will provide the system with information on the user's current circumstances and conditions (environmental data). Examples are weather, season, day of the week, time, location, etc. Needless to say that my.Context will be the key driver for my.AI: there is no AI without data.

6.3 My.AI

To be able to create a personalised my.Platform Digipolis has developed a strategy in which multiple applications and projects are easy to integrate and connect with multiple AI engines.

By personalising apps in my.Platform based on machine learning, the added value of AI in a smart and user centric digital experience is absolute. Mind, my.AI should not be seen independently from my.Context and my.Platform. My.AI delivers personalisation to my.Platform and therefore it relies on my.Context. The latter serves as data source providing historical and real-time data, allows for the creation of machine learning algorithms, and applies them in real-time. Based on my.AI, for example, only the user's relevant applications at a certain time are shown on my.Platform. As a matter of fact, even the content of the given applications will vary depending on the particular situation and personalisation.

7. Conclusion

The ultimate goal is to use the gathered context to build a smart and automated software enabling mind blowing user experience in the City of Antwerp's public services. It is the intention to make the software do the work instead of the user/customer. In other words, let the system discover the patterns by using AI, let the system inform the customer about the potential next steps or processes, and, if the customer agrees, let the system perform automatically the suggested actions.

Digipolis is convinced that DXP is an important added value in providing the necessary building blocks for a state-of-the-art user experience in public service delivery, thus allowing to migrate from mainly e-governmental towards a full-blown my.Government service delivery. A platform aware of the user's needs, even before made explicit, and by executing automatically a series of time consuming tasks no one should be wasting time on, rises great expectations for the future improvement of the modern city consumer's quality of life.

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