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Kopponen, Aleksi

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Empowering Citizens with Digital Twins: A Blueprint

Aleksi Kopponen[1], Antti Hahto[1], Petri Kettunen[2], Tommi Mikkonen[2], Niko Mäkitalo[2], Jarkko Nurmi[3] and Matti Rossi[4]

[1]Ministry of Finance, Finnish Government, Helsinki, Finland
{aleksi.kopponen, antti.hahto}@vm.fi

[2]Department of Computer Science, University of Helsinki, Helsinki, Finland
{petri.kettunen, tommi.mikkonen, niko.makitalo}@helsinki.fi

[3]DigiFinland Oy, Finnish Government, Helsinki, Finland
jarkko.nurmi@digifinland.fi

[4]Department of Information and Service Management, Aalto University, Espoo, Finland
matti.rossi@aalto.fi

Abstract—The exponentially growing amount of digital information and data analysis increase the ability to perceive the holistic situation of people. This paper applies the digital twin paradigm to strengthen a person's ability to utilize information about themselves by creating a digital representation of their situation to support their well-being. More specifically, we propose a blueprint to empower individuals by improving their self-determination regarding their personal data. The blueprint will help service and data providers, both public and private, to develop a common understanding of the role and possibilities of a citizen's controlled personal digital twin of themselves – a Citizen Digital Twin (CDT) – for creating people-centric solutions. The blueprint also provides a rational framework for service development based on Citizen Digital Twins and serves as a basis for strategic guidance of service development. We demonstrate this with a case study of confirmation class students.

Index Terms—Digital Twins, Citizen Digital Twin, People-centric, Information Management, Transparency, Service Development, Service Ecosystem, Well-being, MyData

1 Introduction

With the exponentially growing amount of information in the world, the option to tailor services for citizens at different life events is becoming a reality. To reach this goal in a people-related yet proactive way, data of various origins needs to be combined so that service providers in different sectors can take into account the overall situational context, as well as cross-sectoral opportunities, when providing their services in a people-centric way [1].

The right to create an overall picture of a person can be vested in three different actors; a public authority, a private actor, or the individual themselves [2]. In reality, power is exercised by all three parties and each society defines its own boundary conditions for the exercise of that right. Furthermore, citizen-centricity has been considered as a key factor for successful e-governance [3].

The MyData initiative[1] aims for a transformation where a person has the right and opportunity to explore information about themselves. In essence, the individual can combine data originating from different registers and databases instead of municipalities and other data owners controlling the data. The initiative has acted as inspiration for the research done in this paper, as well as helped to communicate the importance of merging data from private, public, and societal sources.

This paper introduces a blueprint for Citizen Digital Twins (CDT) that allows a citizen to create a digital twin with all the data that pertains to the citizen themselves, similarly to MyData. The basic idea behind the CDT is to help people to form a big picture of their own lives. The CDT will not only be limited to government data, but data resources in other sectors can also be utilized. The CDT helps a person perceive their own situation and to become empowered to act for their own good. For service providers, it serves as an informed basis for strategic guidance of service development in people-centric well-being strengthening solutions. The CDT also enables automatic provision of public and private services to the citizen in various situations and events in life.

1. https://mydata.org/finland/

SIDEBAR: DIGITAL TWINS IN A NUTSHELL

The digital twins (DT) paradigm [1] has emerged in the context of cyber-physical systems (CPS), where physical and software components are deeply intertwined. They each operate on different spatial and temporal scales, exhibiting multiple and distinct behavioral modalities, and interacting with each other in a myriad of ways that change with context. Hence, to apply the digital twin approach, three parts are needed – a physical product, a digital product, and a relation between them. This approach enables development, monitoring, surveillance, debugging, training, and so on.

While originating from the industry, the digital twin paradigm has spread to other disciplines and has been applied in various ways in different domains for many purposes. For example, an organizational digital twin can be created using data that passes through an organization's assets, people, and functions [2]. However, the digital twin of a citizen s a new idea and scienfic research on the topic is therefore lacking. The most widely accepted definition to our knowledge is the work of El Saddik [3], which defines digital twins as "digital replications of living as well as nonliving [sic] entities that enable data to be seamlessly transmitted between the physical and virtual worlds".

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The CDT depicted in this paper is a citizen's own tool, like a mirror through which a citizen creates a digital representation of themselves to increase awareness and understanding of their own situation and multi-dimensional well-being. The CDT creates a way for the citizen to reflect on existential questions in which a person should be aware of their own situation to some degree, but in such a way that does not affect their own well-being. By well-controlled sharing the information to service providers, the citizen can receive suitable services from service ecosystems at the right times.

2 DIGITAL TWINS, MYDATA, AND SELF-MANAGED WELL-BEING

Information about people has been collected for centuries. Data has been accumulated in various ways, usually on paper and later digitized or directly as digital data. The purpose of collection has typically been an organization's or administration's own need for records and to develop services to match more efficient service production. As a general rule, registry data has hardly been offered to people for their own use as it was never the purpose of that data. Over the past decade, MyData (https://mydata.org/) has emerged, with the goal to make people-related data better utilized by the people themselves. For instance, Koivumäki et al. [4] propose that MyData and related services have an impact on how people consider their health as well as how they are diagnosed.

Independently of MyData, regulation has also begun to improve the conditions for people's rights to manage register information about themselves. The European Union's General Data Protection Regulation (GDPR) has challenged data controllers to look at their data repositories from a new perspective. However, MyData and related services are a much broader issue than just privacy. In particular, the question is how to unleash the power of the data through various devices and systems to produce value for an individual person.

As the data is generally individual register data, as such it does not add much value to the person themselves. In addition, if the data is held by an authority, then it is typically in such a form that the power structure itself prevents the data from being used in different ways. Legislation specifically limits the power of public authorities to use information about their citizens. In addition, the data is not designed to be more extensively in contexts other than those for which it was originally designed. Therefore, in addition to aggregation, information must be able to be processed and analyzed in ways that create a holistic meaning for the target person instead of just compiling individual registry data.

The preconditions for information management and data processing have increased significantly due to digitalisation, technology, analytics and the increased use of artificial intelligence. The world's most valuable companies are growing with digital information-based businesses. The world's most efficiently governed societies rule with digital information. Thus, both companies and public authorities exercise power in relation to other actors with the information resources in their possession, increasing their own value in the surrounding society. One way of exercising power is commonly known as the Big Brother society, as coined by George Orwell in his novel, "1984" [5]. The term refers to a society whose citizens are exposed to the control of a public authority. It is typical for a Big Brother society to collect information about actors in the society by all possible means to improve an authority's situational awareness of said actors, which includes both citizens and organizations. A holistic picture of the various actors in society increases an authority's control for its own needs.

In contrast to data used for control needs by various organizations, let us envision turning the tables and using the data to empower citizens for their own well-being. A manifestation of this change in perspective results in an opportunity to create a Citizen Digital Twin (CDT), based on data available from different sources. As an extensive literature review [6] of the topic shows, portraying people

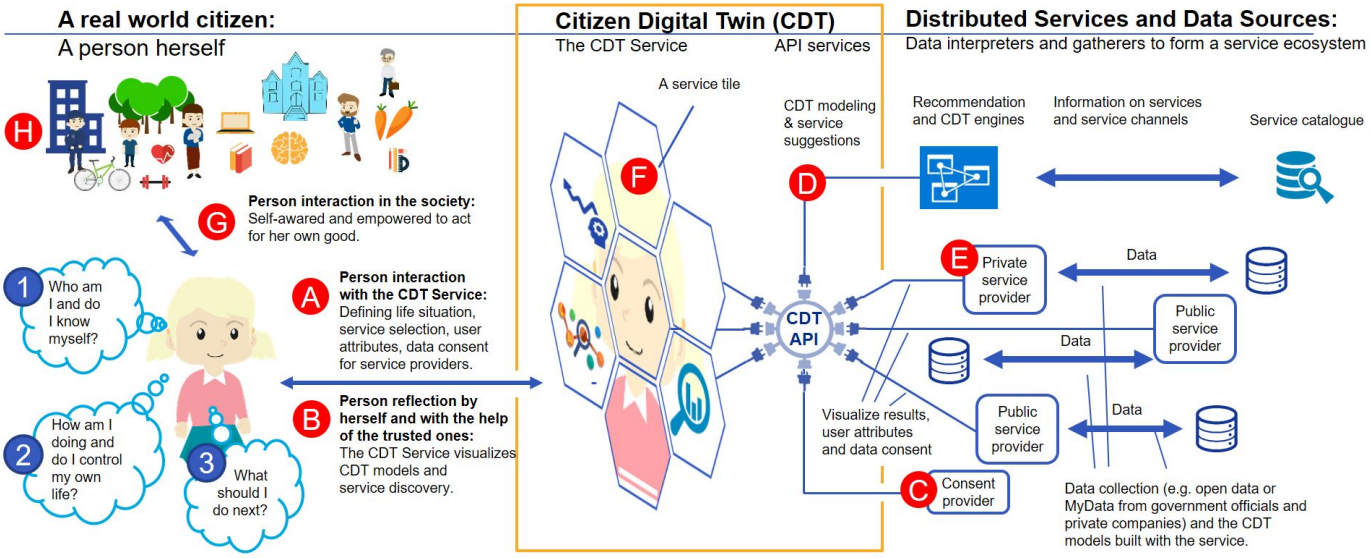

Fig. 1. The conceptual architecture of the Citizen Digital Twin (CDT) and its interactions with a real world citizen and distributed services, data sources and other related services through CDT API.

as a digital twin is a novel area of application for the digital twin model. The CDT can be used to monitor one's own situation, as well as to investigate possible new paths enabled by personal actions. However, unlike previously proposed [7], the view need not be based on self-collected data but municipal and governmental data can be included as well.

3 Towards Citizen Digital Twin: Key Principles

The purpose of the CDT concept is to support a person's own situational awareness of their well-being and what activities and services can improve it based on their data. Therefore, the CDT must be as easy to use as possible for the citizen such that it will help reflect on their situation, for example through the questions mentioned below:

1) Who am I and do I know myself?
2) How am I doing and do I control my own life?
3) What should I do next?

The situation created for a person and supported from the CDT enables a versatile examination of one's own situation. Here, we use a framework that describes holistic well-being in eight dimensions [8], including health, education, personal activities (incl. work), political voice and governance, social connections and relationships, material living standards, environment, and insecurity.

With these dimensions, the CDT forms a balance sheet of a person's holistic state of well-being that visualizes the diversity of a life situation with its weaknesses and strengths. The view we are proposing is adapted from our previous work [9] as well as from the work of Kaivo-oja et al. [10]. Here, the view culminates in the following principles, applied when forming the CDT:

Principle 1: Be Humane. To help people to be aware of what the system is doing, the use of CDT shall use understandable human language and concepts.

Principle 2: Be Reflectable. The CDT shall reflect the users themselves and their preferences for other services as faithfully as possible.

Principle 3: Be Inclusive. Humans are different, and for this reason, the CDT shall enable composing the data model from different services based on the user's specific needs. New data about the citizens from different services should be used to complement CDT and make it more accurate.

Principle 4: Be Customizable. The CDT shall enable the user to customize and personalize the data model by adjusting parameters for algorithms, and managing how and by whom the data can be accessed.

Principle 5: Be Empowering. The CDT shall be available at all times, allowing other citizens' CDTs (peers) and service ecosystems to serve the citizen in reliable and convincing ways, and in real time. The CDT data must reliably reflect the current state.

Principle 6: Be Transparent. The CDT shall preserve the user's privacy and cyber security. The data must be stored safely and be accessible only with the user's consent. The citizen shall always be able to know who or what has used their CDT data and for what purposes.

4 Blueprint: Operational Model and a Reference Architecture

The blueprint for a CDT consists of three elements, as depicted in Figure 1:

- the real world and the individuals as real persons;
- a digital world, which consists of numerous data sources provided by different services;
- the CDT can be customized by the individual based on available data sources and services.

The proposed operational model is marked in Figure 1 with capital letters. The interactions that form the model are presented in detail in Table 1, together with their relation to the design principles in Section 3. Obviously, the interactions need not be executed in sequence.

TABLE 1
Elements of Citizen Digital Twin processes explained.

Label in Fig. 1	Description	Support (Principles in Sect. 3)
	Citizen – Citizen Digital Twin	
A	• Person describes their situation by interacting with the *CDT Service*. They can give *consent* to utilize their MyData if they wish. • Based on the description, the *CDT Model* is formed by the *CDT Engine*. • The *recommendation engine* suggests *service tiles* that fit in the CDT Model. Service tiles are UI services controlled by various *service providers* through CDT API. • Person selects service tiles of their choice and starts interacting with associated service providers with that part the CDT Model they choose.	Be Humane, Be Empowering, Be Customizable
B	• By interacting with a chosen service tile with the CDT Model, a person reflects on their life in a given situation or event by themselves and with the help of the trusted ones by augmenting the process with the related questions such as 1, 2, and 3. • The CDT model acts as a mirror for the person. The model gives the person a better chance to look at their situation and learn to act for the best of interests of themselves in their lives.	Be Reflectable, Be Humane
C	• Person may authorize or deauthorize the service provider to access information about themselves, such as MyData, by a *consent provider* through CDT API to improve the reflection.	Be Inclusive, Be Transparent, Be Customizable
D	• A CDT Engine, a recommendation engine and a *service catalogue* are utilized through the CDT API. • There can be several third party engines and service catalogues connected through CDT API.	Be Reflectable, Be Empowering. Be Transparent
	Citizen Digital Twin – Data sources and services	
E	• Service providers, who provide end-user services, support people to reflect on their situation against the given CDT Model. They also govern CDT Models people have build with their services. • Service providers utilize the person's authorized data sources and user attributes, such as subjective well-being data, through interaction with the service to improve reflection and visualizing the results in the service tile.	Be Inclusive, Be Transparent, Be Customizable
F	• The CDT Service provides the visualizations as tiles which are related to certain "topics" for the person. A tile is a service provider's interpretation of the person's situation based on their data.	Be Reflectable, Be Humane
	Citizen – Physical World	
G	• Based on the reflection process, the citizen acts in the physical world and interacts with its other entities, like people, things and services, which may produce additional data (see H).	Be Reflectable, Be Inclusive
H	• Data is being collected from the physical world processes that the citizen has authorized (see C).	Be Inclusive, Be Transparent, Be Customizable

Reference Architecture

Fundamentally, the implementation of the CDT concept as proposed above needs three different architecturally important elements. These are the CDT Model, CDT Engine, and CDT API. They play the following roles in the design:

- CDT Engine(s) play the role of data aggregator(s) in the model. They seek and compile information from databases and services, prepare combined datasets for data processing, and return the build CDT Model back to the service provider to be further utilized.
- The CDT Model is the representation that the individual has created of themselves based on inputs from potential CDT Engines as well as their own. The CDT Model defines which data and data sources are meaningful, as well as help to control the amount of data that is provided to the user.
- CDT API provides access to data and enables visualization, data consent, and potentially more complex operations such as scripting. In addition, the API can be used to configure CDT Model(s) and CDT Engines for personal use.

Obviously these three components are private, but we believe they can be be treated in accordance with the spirit of the MyData initiative. Furthermore, as a matter of convenience, the user services can be made selectively available for public or private actors, as long as privacy concerns are met.

In addition to the components that reside in the cloud, a user interface is needed that is intuitive and easy to use. Marked as a mirror consisting of small tiles, each of which represents a different services in Figure 1, this interface needs to be customizable but simple enough for a number of use cases.

5 Real-Life Use Case

One can consider societal factors as something to be mimicked with digital twins. As an example, let us consider a practical initiative that is presently ongoing in Finland – the national artificial intelligence program AuroraAI [2] and one of its sub-programs where the goal is to assist 13-16 year olds with their personal well-being.

An experimental implementation of the CDT in this context focuses on a target group that can form a sufficiently clear entity with a clear life event and a broad representation of the target population of Finland. Confirmation class, which covered 46 824 young people in 2019 (44 868 of them were 15 years old corresponding 77,4% of the age group, 1 956 of them were aged 14 or 16), was chosen as such. Most often, confirmation class is attended in Finland in the year a person turns 15 years old. Confirmation classes are organized under the responsibility of the Evangelical Lutheran Church of Finland, which is related to both faith

2. https://vm.fi/en/auroraai-en

and life as a Christian. During the class, students work with other students, adults, and older youths to consider issues related to their developmental stage, including values of life, relationships, sexuality, family, environmental issues, responsibilities, and justice. Consequently the class provides the young person an opportunity, time, and space to look for answers to questions about their own life.

In this case, the church acts as a service provider (right-hand side of Figure 1) whose service is activated as a service tile for the young people to use as part of their confirmation classes. These take place annually, starting between January and February and continuing until the summer when confirmation camps take place. So far, situational analysis of a person's well-being is formed in confirmation class through class activities, such as practices and dialogues. However, the analysis work is not digitized at the moment. In the realization based on CDT, technological capabilities will be made available to the young people themselves. This allows them to make their own journey to their own basic issues and, at the same time, create a personalized CDT from real situations in their lives.

Co-designed by the youth and the church, the CDT enables the young person to find the best possible solution for managing their own lives with the service provided by the church. It is formed through the CDT Service in which the young person forms only one piece at confirmation class. The church is therefore just a one service provider in supporting people in understanding their own well-being. The decision to choose the services people want to utilize remains with the people themselves, in this case, the young person.

Table 2 describes the process of forming the CDT Model based on the blueprint from the perspective of a young person going through their confirmation class. According to Figure 1, Table 2 is divided into three columns (young person in a confirmation class, CDT, and related distributed services and data sources for the use case) which look at the different phases from the young person's point of view and what happens in different parts of the figure during that phase. At the same time, the labels in Figure 1 are connected to Table 2. Here, a third sector service *NäytönPaikka* (https://naytonpaikka.fi/) is planned to be used by the church which defines the content of dialogues between a young person and a service tile operated by NäytönPaikka. Implemented in Finnish, NäytönPaikka is an online service that acts as a personal tool, allowing a person to stop and reflect on their own life. A variety of tools are available, such as a network map, timeline, and a ready-made resume template.

During 2020-2021, the CDT Service illustrated in Figure 1 are designed and created with the young people familiar with the confirmation class and those who will be involved in the work. Additionally, the church and its employees join the design phase in accordance with the principles of service design. So far, the current confirmation class process has been modeled to understand how the confirmation supports the young person in perceiving their own well-being and life situation. The confirmation class process modeling revealed that the young person is supported in strengthening their situational awareness through different class themes. Thus, building the CDT Model and utilizing it for the benefit of oneself was divided into several phases (rows in Table 2):

- Phase 1: Defining the situation in life,
- Phase 2: Sharpening the situation in life,
- Phase 3: Reflecting on the situation in life,
- Phase 4: Exploring suggested services,
- Phase 5: Interacting in the society.

Next, the work continues by implementing Phases 1 and 2 in five different workshops, where the CDT will be refined from different perspectives by the young person themselves. In Phase 3, the young person starts to reflect on their situation with the help of the refined CDT Model. In Phases 4 and 5, they explore services that are suggested in their given life situation by the CDT Model and start to live life for their own good in society. The refined CDT Models are used exclusively by the young person, which will support self-knowledge management and perception of self-image in the future.

6 Discussion

The intention of the CDT is two-fold. Firstly, we seek to support individual citizens to reflect on themselves and their situation against their virtual representation images (”Digital Me”) and act for the benefit of their own good. The virtual representations are based on (i) the data given by the individual citizen personally (user attributes) and on (ii) public, private, and other relevant data sources linked to the citizen as permitted by personal preferences and settings. Service providers support the modeling by producing interpretations of the citizen's data permitted. Secondly, we want to enable public and private service providers to offer appropriate and timely services for the citizen following their accessible CDT Model. This can be supported by creating novel service ecosystems to support peoples' well-being.

At its best, and by following the design principles, our blueprint creates new market mechanisms in a way where market players primarily seek to strengthen people's well-being and thereby create new business. The CDTs can create a new kind of market data, so-called cluster data, in which market participants understand the real situation of people's overall well-being as market data. They are then able to create a new kind of supply to meet the real needs of people in these particular clusters. The more accurately these types of offerings are formed, the better they serve the real needs of the people.

Unlike Human Digital Twins virtualizing human physical bodies or situations in the medical domain [11, 12, 13], CDT is a virtual representation of the human ”life”. It particularly concerns psychological and social elements of well-being in a chosen life situation or event as described in the use case in Section 5. It should also be noted that the state of well-being is a subjective concept and its definition cannot be the responsibility of one party alone. Therefore, the CDT Service is an easy-to-use tile mirror in which a person can assemble several service providers to support self-reflection and service recommendation. Hence, while our pilot use case described in Section 5 is directed to one specific type of citizens (young people) and their particular life situation (confirmation class), the AuroraAI program will apply the generic CDT blueprint for many other classes

TABLE 2
Realizing the experimental use case with the Blueprint

CDT Model building phase	Definition	Real world citizen: Young person in a confirmation class	Citizen Digital Twin (CDT) of the young person in a confirmation class	Related distributed services and data sources for the use case
1	Defining the situation in life	A young person attending a confirmation class begins to map their own situation in a confirmation class meeting. The mapping is done with the help of a pre-selected CDT Service by the church (A in Fig. 1) together with older peers and the confirmation class staff in a safe environment for the young person. The CDT Service asks the young person eight questions in six different meetings, each related to a different aspect of the young person's well-being, such as questions related with dating and family relationships. Questions are discussed with safe adults before being answered. After the discussion, the young person answers the questions from their own point of view in the CDT Service. Eventually, they see a summary of their first answers and is given the CDT access code that allows them to continue to enrich the CDT Model and refine their life situation later on. The young person knows that the system doesn't know their real identity.	At the request of a young person, the CDT Service activates the pre-selected service tile (F) that communicates with the pre-selected service provider (in this experiment, a third sector service NäytönPaikka* is planned to use) (E) via the CDT API. NäytönPaikka sends questions, such as dating-related questions with a self-reflecting questionnaire to the service tile, which functions as a user interface for a young person. User answers are sent to NäytönPaikka through the CDT API accordingly. In order to build the CDT Model, the service provider may require MyData (in this experimental realization, MyData will not be used by NäytönPaikka), for the utilization, in which case it requests permission from a young person. A separate service is responsible for licensing to utilize MyData (C).	NäytönPaikka is activated after receiving a service request from the service tile through the CDT API. After identifying the new user, the service provider creates a new user ID and sends the first queries to the service tile to collect the user profile information, such as self-reflection on dating. The service provider compiles the responses received. Once NäytönPaikka has received a sufficient amount of information from the user, the information is compiled into a packet and sent to the CDT Engine (D) for citizen digital twin modeling. The CDT Engine returns the created CDT Model to the service provider, who presents it to the young person through the service tile.
2	Sharpening the situation in life	At the next confirmation class meetings, the young person will continue to determine their own situation. At each meeting, the young person is asked by the CDT Service questions about different parts of their life, such as family, friends, living environment, hobbies, and schooling. Each time, the young person refines their own situation together with the adults by using the given CDT code to activate their model in the CDT Service. Each time, the young person continues to enrich the CDT Model stored in NäytönPaikka has gathered responses from previous encounters, the CDT Model becomes even more accurate.	The user enters the CDT code into the CDT service, which is identified as the code of a particular service provider (in this case, NäytönPaikka). The code is passed through the CDT API to that service provider, which activates the accounted CDT Model matching the given CDT code to the service tile for the young person to enrich. The young person decides to refine the model, so NäytönPaikka asks the user more specific questions about the selected area of life that the user wants to refine. Eventually, NäytönPaikka returns the updated CDT Model to the user. This step can be performed several times (in the experimental realization, the model is supposed to be refined five times).	NäytönPaikka receives the CDT code that corresponds to the stored CDT Model in NäytönPaikka's database. NäytönPaikka returns the CDT Model to the service tile as it is. The young person sends a service request to refine the model in the selected area of life, in which case NäytönPaikka launches a set of questions intended to refine the CDT Model. The responses are collected as a package and forwarded to the CDT Engine for integration with the previously made CDT Model. The CDT Engine returns the refined CDT Model that the service provider sends the service tile to the young person for viewing.
3	Reflecting the situation in life	The confirmation class for young people culminates in a confirmation camp that lasts 5-7 days. During the confirmation camp, they get to know both their religions and themselves. During the camp, they reflect on their own well-being, their life and its direction, by using the CDT Model. Made and enriched during the confirmation class meetings before the camp, it acts as a mirror for the young person in the camp. The model gives the young person a better chance to look at their situation and learn to act for their best interests in life (B).	The user requests to view the processed CDT Model with their own personal code. The CDT Service passes the code to NäytönPaikka via the CDT API. NäytönPaikka returns the according CDT Model for the young person to view in the service tile.	NäytönPaikka receives a service request through the CDT API to retrieve the CDT Model to the young person corresponding to the given code. NäytönPaikka returns the CDT Model corresponding to the code to the service tile via the CDT API.
4	Exploring suggested services	When the young person feels that they agree with the situation described in the CDT Model, they ask the CDT Service to suggest the services that are typically the most useful in the life situation shown in the CDT Model. For example, a young person has been identified as a person who needs public authorities, companies and technology to help them take care of their own well-being. The CDT Service tile propose new services accordingly.	The young person asks the CDT Service to suggest the services that best fit the given CDT Model. The CDT Service forwards the request as well as the corresponding CDT Model to the recommendation engine, which returns a service set in response through CDT API. (D)	The recommendation engine receives a service request through the CDT API. The service request is accompanied by the CDT Model and a request to suggest the best service offering for the CDT Model. The engine compiles the services that best meet the needs of the model from the service catalogue and forms a service package, which is returned to the CDT Service via the CDT API. (D)
5	Interacting in the society	Once the young person has formed the CDT Model of themselves and reflected on their situation, and services have been suggested based on the service catalogue, the young person has been empowered to act in society for their own good (G). By living in society and utilizing different services, they increase their own awareness (H) to further refine the CDT Model. In addition, they can form a new CDT Model with a different service provider to support other life situations.	The CDT Service presents the CDT Model according to the code entered by the young person and the related services whenever they want to use them in their life. They can also start creating a new CDT Model, in which case the CDT Service will initiate forming the life situation from the beginning or utilizing an existing CDT Model, depending on the user's decision.	Service providers describe their own service information in the service catalogue, from which the recommendation engine reads the service offering and suggests to the user suitable service tiles for forming the life situation by CDT modeling. The CDT Model already created by the user may be viewed by the user upon request to the service tile.

of citizens, their typical life events, and associated services [3]. For example, such a case could be middle-aged persons

3. https://bit.ly/3mZSX9z

facing unemployment due to shutdowns of their current work places. Similar considerations are also being made in other countries [14]. Furthermore, Semenova [15] takes one step further and discusses "government as a platform" approach, which aims to design a "customer-centric model" of public administration to solve the life situations of citizens through tailored cross-cutting services. In this approach, the state implements a digital platform for the development of digital twins, which are defined as single digital profiles of citizens, by which a person identified in the state platform is able to interact with the ecosystem and receive services according to their needs. CDTs could also be interconnected, for example with digital twins in the built environment, allowing CDTs to interact digitally with other digital twins. Cognitive abilities could also expand the potential of CDT as "learning assistants", resulting in cognitive digital twins [16]. For example, a CDT would be able to anticipate the needs and behaviors of its physical counterpart well before unwanted human behavior occurs, which could help people avoid events such as exclusion.

As demonstrated in other domains [17, 18], accepting that constructing digital services which truly help people leads to the conclusion that a more holistic view of data and its management is required. However, to this end, there are two obvious limitations that require further consideration. Firstly, existing information production is mainly based on the needs of the administration's own service production, and wider utilization for the benefit of people is not even planned. Secondly, the European Union's General Data Protection Regulation (GDPR) seeks to improve people's fundamental rights to information.

As highlighted by the design principles, the CDT blueprint proposal meets the above challenges in the following ways. In general, the CDT strengthens people's ability to understand their own situation holistically by utilizing existing information found from public, private, and other databases. The better a person understands her/his own state of well-being, the better (s)he is able to act for her/his own good. Secondly, against the CDT Model, people can be offered tailor-made services from all sectors. While our primary viewpoint has been that of individual citizens in this paper, a potential area of elaboration is to investigate the CDT more from the service providers' point of view. This calls for additional technical capabilities – such as means for service providers to search and connect publicly opened CDTs – but it could also open up opportunities for new service innovation. Furthermore, special actions are needed to establish standards and practices regarding security and privacy, as evidenced by a recent case in Finland [19]. To this end, CDT can act as a framework under which such actions can be taken in a coordinated fashion.

To realize systems that follow the CDT blueprint architecture outlined in Figure 1, a number of technical considerations must also be taken into account. Firstly, the development of the CDT API must be done in close cooperation with a sufficient number of service providers to make its implementation as easy and effortless as possible. Secondly, the CDT Service is a platform that should allow the most exploitable interaction between a person and a service provider through a service tile.

In summary, the CDT blueprint proposed in this paper leads to several avenues for further research. The most concrete direction is to complete the use case realization proposed in Section 5, and reporting the related results and experiences. Such reporting will also act as the final, tried and true validation of this work. In parallel, the initial blueprint proposed in this paper can be extended and elaborated in many respects. In particular, different CDTs of the same individual citizen, or possibly also different citizens, could be interconnected. This requires additional technical capabilities and, more importantly, creative service development in utilizing them.

7 Conclusions

To conclude, while we refer to using Digital Twins, the fundamental goal is very different from the traditional use of the technology. Instead of DTs being used to speed up lead times and reduce risks in product development and operations, CDTs are about digitally supporting people's understanding regarding their own situation and multi-dimensional well-being, opportunities to utilize the best supporting services, and, at least potentially, positive change in their lives.

In this paper, we have focused on the concept itself, which means overlooking numerous technical challenges that emerge when integrating data from numerous public and private systems. Furthermore, we did not consider in detail the deeper position regarding how an individual is made to understand or decide on behavioral changes, or to become empowered to act for the benefit of themselves. These topics will, however, form an important piece of future research, to be executed as our pilots are deployed en masse.

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Aleksi Kopponen is a Special Advisor of Digitalization in the Ministry of Finance, Finland. In his current work and research, he focuses on the human-centered, artificial intelligence utilizing digital transformation of a society. Contact him at aleksi.kopponen@vm.fi

Antti Hahto works as a Special Advisor in the Ministry of Finance, Finland, focusing on the technological aspects of utilizing artificial intelligence in digital transformation of the Finnish society. Contact him at antti.hahto@vm.fi

Petri Kettunen is a university researcher at the University of Helsinki, Finland. Contact him at petri.kettunen@helsinki.fi

Tommi Mikkonen is a Professor of Software Engineering at the University of Helsinki, Finland. Contact him at tommi.mikkonen@helsinki.fi

Niko Mäkitalo is a Postdoctoral researcher at the University of Helsinki, Finland. He is Associate Editor of IEEE Software Blog and a member of ACM. Contact him at niko.makitalo@helsinki.fi

Jarkko Nurmi is an IT Architect in DigiFinland Oy, a state-owned development company. Contact him at jarkko.nurmi@digifinland.fi

Matti Rossi is a professor of information systems at Aalto University School of Business, Finland. He is a past president of the Association for Information Systems. He is the past editor in chief of Communications of the Association for Information Systems. He is a member of IEEE, ACM and AIS. Contact him at matti.rossi@aalto.fi