Digital Twin – What is it?

Brief explanation for the customers and project partners

Our world now consists of increasingly large number of diverse systems operating mostly independently e.g. in a building these are HVAC, electrical, water, lightning, fuels, waste collection and disposal, security control, fire, etc. In a bus station there could be additional systems for vehicle scheduling, control, ticketing, passenger flows and accidents management, maintenance services and so on.

At the same time, the bus station in a building is a part of a bigger system that include a transportation vehicle (as complex system itself), many such vehicles (a bigger system), their association and operations related to specific transportation nodes, city topography and routes, passenger flows, time (day and season), weather conditions, economic situation in a country, and many others.

These physical systems including passengers, have various levels of support by the different automated systems and services, and in its operations become increasingly dependent on reliability, trustfulness, accuracy and intellectual capacity of these systems to handle complex processes and its variety of optional disturbances.

Even a transportation passenger is now being transformed from a human being (as in 60 years ago) into some kind of "cyborg" who supplements his/her natural intellectual and physical abilities with various services that are available in real time at own mobile phone that can understand speech, implement commands, recognize face, help in solving various complex tasks (e.g. routes, current status of events in a city (traffic, air pollution, accidents, demonstrations, terror acts, etc), make payments, access news from social networks and many others.

All these systems are increasingly interlinked and the processes, taking place in each of them, become dependent on many others creating **dependency chains,** i.e. if something happens in one system, it can impact many others with different levels of intensity and consequences.

Actually these big interlinked systems become present in both physical and virtual worlds as it is show in Fig 1. These two worlds are linked via all optional connectivity solutions such as Internet, cellular, WiFi, LPWAN, cable networks, etc. The processes in the Physical world are represented in the virtual world by various measurements and data received from meters, sensors, video cameras, IoT, automated systems and various observations by people who enter it into relevant databases and information systems manually.

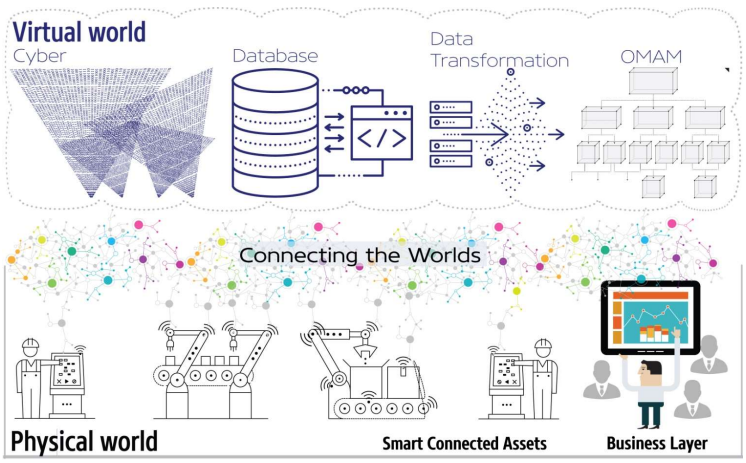

Figure 1 Digital twins linking the worlds

While we understand and can cope somehow with the objects

existing in the Physical World (presented at the low part of the drawing), we do not have any chance to deal with the virtual world consisting of binary zeros and ones continuously transformed into other zeros and ones with high speed computing and stored in very complex database tables.

The only way for us to see and interact with the Cyber Objects existing in the Virtual World is to use computing devices like mobiles, tablets, notebooks and PCs (on the rights lower part of Fig.1).

The hierarchical structure OMAM (Open Metropolitan Assets Model in the right upper corner of the drawing) represents the objects existing in the both worlds. It makes it easy to understand by people who used to describe the complex systems as hierarchies. In the building it represents its structures (e.g. floors, corridors, rooms, and various systems operating in these structures – ventilation, cooling/heating, electricity, etc). In the city it represents its districts, local areas, streets, buildings, rooms, tubes, wires, switches and so on.

Taking into consideration all these realities the definition of the digital twin is as follows:

For us as humans, **Digital Twin is the applied model of the complex cyber-bio-physical system** that we need to define, develop and use **as some approximate copy of this big system** helping to monitor and manage the magnitude of processes and objects existing in the both worlds.

Digital twin can represent many its sub-systems and their objects as hierarchical structure of nodes having any necessary number of levels. Each node can be intelligent having own computing resources, processing methods, indicators, data elements, sensors, video cameras, constants and the channels to interact with us as users (we can have various roles, interests and rights in such interactions e.g. operator, manager, or public). It is important that each node can calculate its own sustainability, resilience and performance status in real time and report it to the upper level of the twin model and relevant users. The channels of user interactions can include dashboards, reports, widgets, augmented and virtual reality, voice, etc presented at common devices such as mobiles, notebooks, gadgets. The vision of the twin in the PharosN Navigator is presented in Fig 2.

In the cyber space such twin is realised in a complex database(s) and variety number of processing algorithms including AI, blockchain, etc. The twins developed on the computing platform PharosN run in real time transforming big data streams from large number of data sources (sensors, meters, IoT, video cameras, spreadsheets, databases, automated systems, mobiles, webs, etc) into rich set of custom services to monitor, analyse and control the Big target System of Systems presented in the both worlds. The examples of the twin systems and objects presentation at Smart City Monitoring Dashboard are presented at Fig 3 and its view on the city map at Fig 4.

PharosN platform has some tools to define the digital twins and like them to various data sources. They provide possibility to make the twins and evaluate them prior to linking to actual sensors and systems. For this purpose the PharosN data stream simulators are used that represent the measurements of real physical and cyber processes in real time. It allows experimental testing of various concepts, methods and solutions with minimum costs before the implementation.

We plan to apply the novel PharosN IoT platform, developed by company GOLEM Integrated Microelectronics Solutions GmbH, Austria and its model builder tools for the development of the twins for key project transportation intermodal systems that need to be studied and prototyped during the project implementation including railway and bus station.

The online demo of the twin models of a Smart City and Manufacturing enterprise are available at the portal http://pharosnavigator.com.

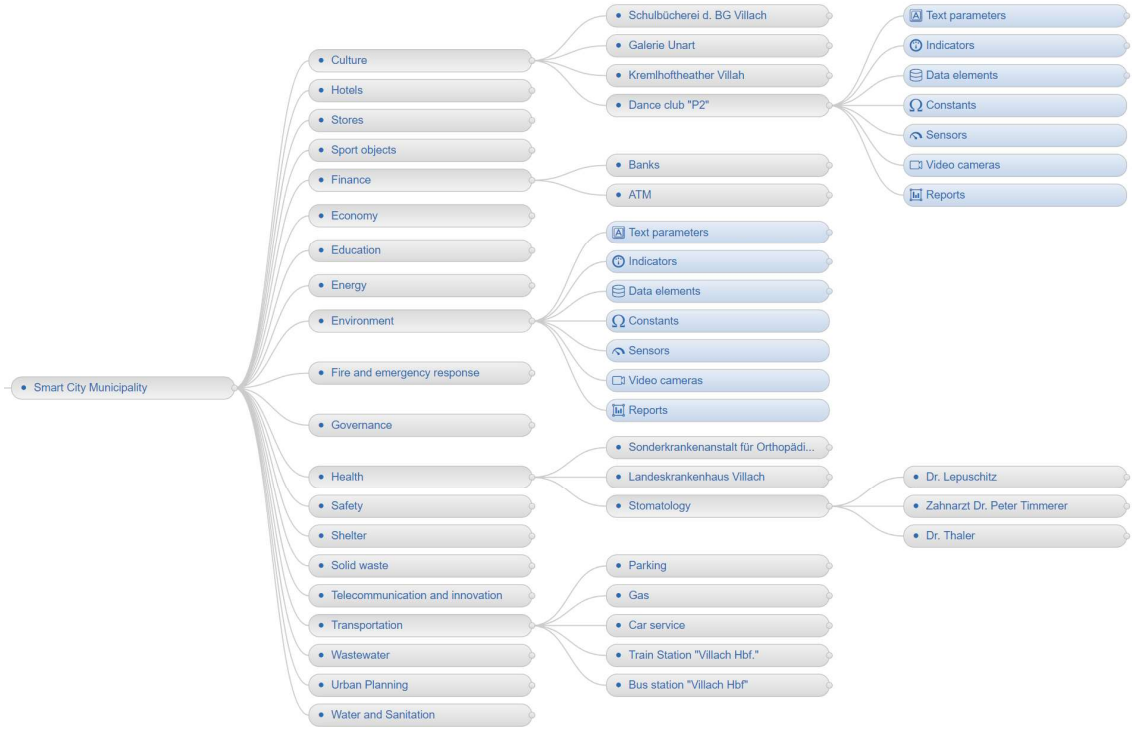

Figure 2 City twin model view as hierarchy of nodes in PharosN Navigator widget

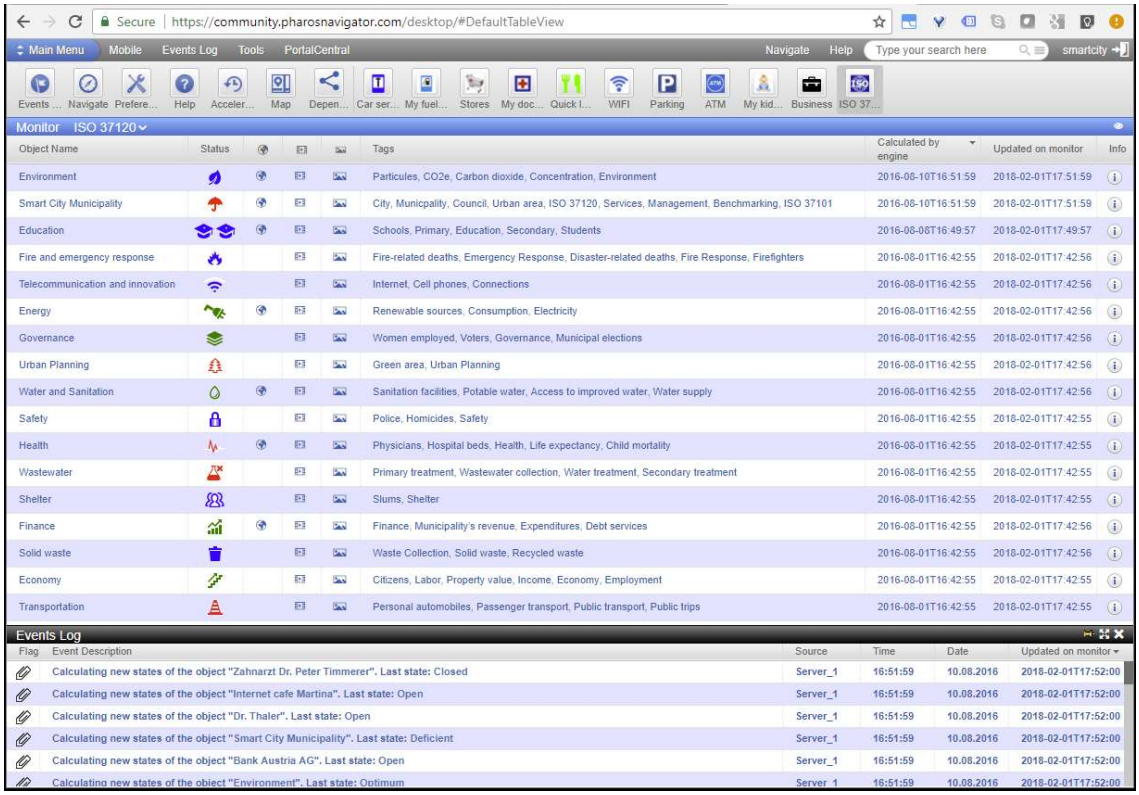

Figure 3 City twin systems' and objects' view in interactive monitoring dashboard at Smart City Monitor

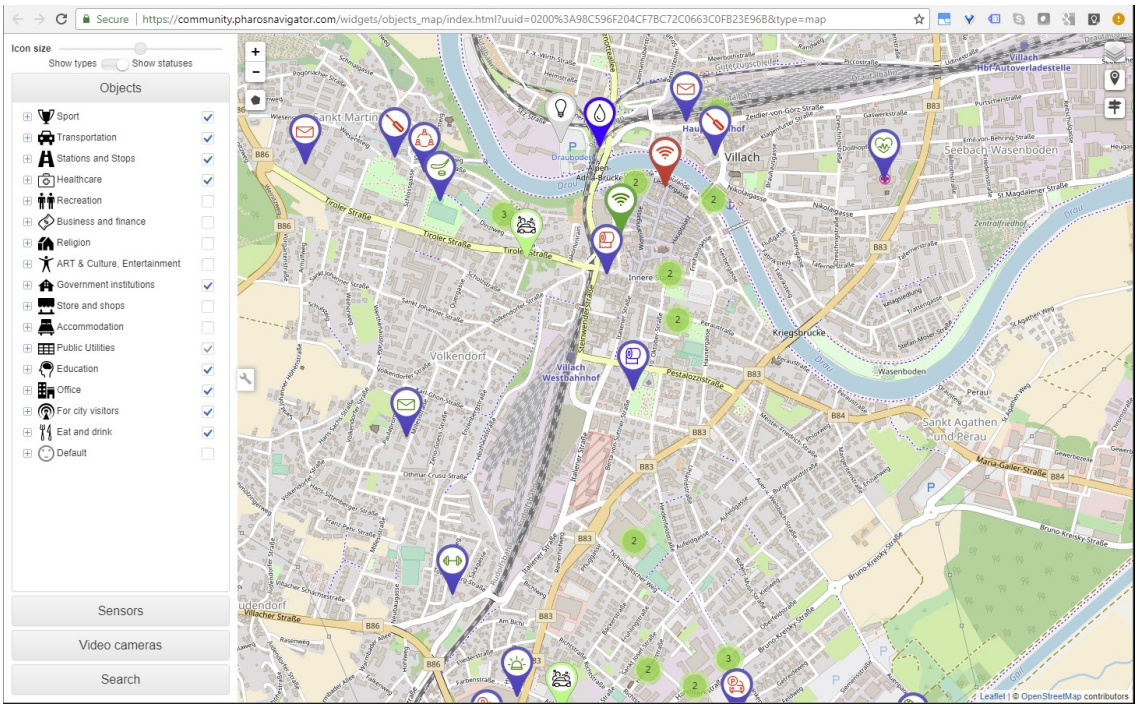

Figure 4 City twin objects presentation in real time on 2D map, click on a balloon opens its interactive status report