Cloud Federation Usage in Engineering and Construction Sector

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Abstract. The aim of this paper is starting with the description of the current achievements regarding digitalization technologies in the engineering and constructions, to present concrete technologies like the CityGLM, BIM, and the EUBIMTG initiative. These technologies create huge capacity of gains for the constructions sector in all phases, and for all the actors, as constructions digitalization has a huge unexplored potential. In addition, the clear advantage of EU BIM as thematic module in CityGML technology in the generation and management of buildings digital representation of physical and functional characteristics is underlined. In this environment, the cloud-computing paradigm provides on-demand services creating new business models. IaaS of cloud federation can be solve many issues. There is a need strictly and precisely to define the design and implementation guidelines for the used functionalities used. For the requirements analysis a four points list is proposed.

Keywords: GIS, BIM, twin city, E&C, cloud federation.

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1 Introduction

For almost 40 years, now Geographic Information Systems (GISs) are used as industry standards. GIS are computer-assisted systems that are used for the capture, storage, retrieval, analysis and display of spatial data [1]. Since the 80s, they have increase in use and their sophistication has led to new academic interests, which have resulted in an expanding research community in many directions. We have now formalized definitions, categorizations, terminologies and standard data structures, showing a remarkable degree of cross-disciplinary work. Just to mention few of those standards:

- CEN TC287 GIS, for the standardization in the field of digital geographic information for Europe;
- International Standardization Organization (ISO)/TC211 GIS, for the standardization in the field of digital geographic information; and
- Open Geospatial Consortium, as an international not for profit organization

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committed to making quality open standards for the global geospatial community.

Still there are many more opportunities available as result of the application of new technologies, materials and tools. According to the World Economic Forum [10] new technologies in the digital space, will not only improve productivity and reduce project delays, but can also enhance the quality of buildings and improve safety, working conditions and environmental compatibility. In this direction, Building Information Modeling (BIM) plays a central role, as it is the key enabler of and facilitator for many other technologies.

There is increasing interest in the integration of BIM and GIS [7]. Although BIM and GIS applications and environments are quite different, both have strengths, but both also make progress and first steps in new promising technologies like the twin cities environments. As a comparison, we may refer to the BIM that uses 3D geometry based on Industry Foundation Classes (IFC). The ISO IFC standard is primarily used for representing constructively solid geometry, with boundary representation, using Boolean operations. The produced data modeled with IFC are used in exchanging information on-project basis between project stakeholders, and partners. So BIM is used to model buildings and other similar constructions, and structures above the ground, and it is typically used for new buildings, constructions and other structures. Another very important concept regarding BIM models is the decomposition and further specialization of objects in the model. This makes the relation between different objects to be of strong importance.

On the other hand, the GIS systems have a server-focused approach. The focus of GIS data is on the geo-location by using real world coordinates. Geospatial objects in the GIS environment are being related by using those real world coordinates. The role of the GIS modeler is to model existing data, enhanced with other tools or policies. Until now GIS has been proved strong on 2D geometry and now is being standardized with 3D.

BIM and GIS technologies can create strong synergies, when used together in a digital twin environment. The digital twin is a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level. At its optimum, any information that could be obtained from inspecting a physical manufactured product can be obtained from its digital twin [4].

The aim of this paper is to evaluate the opportunities, and describe the business models for the Engineering and Construction (E&C) sector, which the two technologies GIS and BIM create in an integrated digital twin environment.

2 Methodology

The integration of the two concepts (of GIS and BIM) should use the strengths from both of them, in the context of the other. This can be done by using a central model server for GIS like CityGML, with a thematic module for building information modelling based on the EU BIM task force guidelines. This architecture allows us to integrate EU BIM semantics into CityGML. The integration of BIM and GIS generates even more applications from both domains if combined in a digital twin platform. Finally, this new approach can create additional business models for the E&C sector.

2.1. GIS standards and CityGML

There is an increasing interest in building virtual 3D city models, focused on different application areas. Starting from systems for urban planning, to mobile telecommunication, disaster management, and 3D cadaster, further to tourism, for applications in vehicle and pedestrian navigation. The first virtual 3D city models were defined as graphical models, without any additional semantic aspect, and could only be used for visualization purposes, but not for thematic queries. Those systems had also limited reusability of their models in other city models, and thus a more general modelling approach was necessary in order to answer to those information specifications for different applications and fields.

CityGML is the answer to this challenge, as a common semantic information model, enabling the representation of 3D urban objects, and their sharing over different applications. This capability namely is the most important regarding the cost-effective, and sustainable maintenance of a 3D city model. This allows to the developers to sell the same platform to many different customers from many different applications and fields. Again, the applications and the fields vary from city planning, and architectural design, to tourist and leisure activities, vehicle and pedestrian navigation, but also environmental simulations, from mobile telecommunication, and disaster management, to homeland security, and real estate management.

CityGML is designed as an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is implemented as an application schema of the Geography Markup Language 3 (GML3), the extendible international standard for spatial data exchange and encoding issued by the Open Geospatial Consortium (OGC) [6].

The main idea is that CityGML defines the necessary classes and relations for the respective topographic objects in cities and regional models with their geometrical, topological, and appearance properties but also add semantical representation. This way the “City” gains a broader definition including built structures, elevation, vegetation, water bodies, “city furniture”, and more so called thematic modules. The model includes generalization hierarchies combining those thematic modules, as relations between objects, and spatial properties. CityGML can be applied to both large areas and small regions and can be used to represent terrains and 3D objects with different levels of detail simultaneously, different Levels of Detail (LOD) (see **Fig. 1**). LODs are required to reflect independent data collection processes with differing application requirements.

2.2 BIM standards and EU BIM task force

The concept of BIM has existed since the 1970s [2]. There are many different definitions of BIM by providers varying from Wikipedia to the ISO. Most of them describe BIM as a process or method of managing information related to facilities and projects. All this information collected and organized coordinates multiple inputs and outputs. Thus, we can use different representations of physical and functional characteristics, shared and digital. In addition, we can represent built objects like buildings, bridges, roads, or process plants.

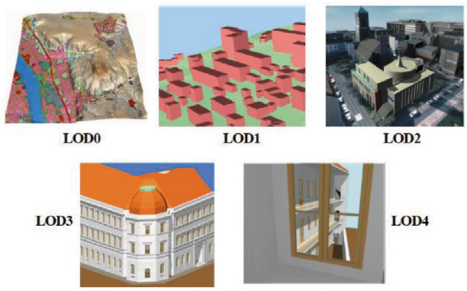

Figure 1: The five levels of detail (LOD) defined by CityGML [6].

A pan-European approach to best practice in BIM was established. The idea is to bring together efforts into a common and aligned approach to develop an excellent digital construction sector. Introducing BIM at a project, organizational or national level raises questions like where to start from, or what to do first and what is that can define it.

Based on the existing experience of implemented until now projects for the successful transformation of the construction sector, EUBIMTG [3], focuses on:

- clearly and specifically defined activities and characteristics, and
- well scheduled and phased implementation of the strategic framework in a realistic period.

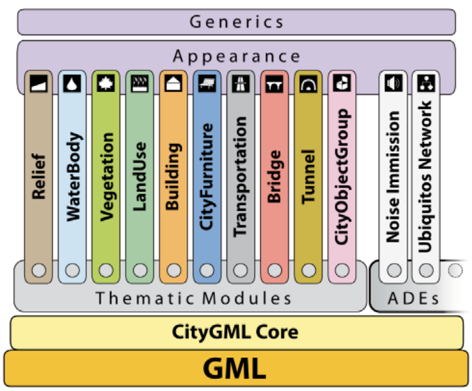

Figure 2: CityGML modularly structured [9].

One particular area where standardization on BIM is needed is the exchange of information between software applications used in the construction industry. The leading organization in this domain is building SMART, which has developed and maintains Industry Foundation Classes (IFCs) as a neutral and open specification for BIM data model. Other standardization work includes data dictionaries (International Framework for Dictionaries Libraries) and processes (data delivery manuals) [5].

2.3 EU BIM as thematic module in CityGML

However, CityGML is modular and covers various thematic areas of city covering buildings. It provides us with the opportunity of incorporating EU BIM standards in the CityGML frame. Again, we have the ability of representing each object in the city the above-mentioned levels of detail (LoD) (see **Fig. 2**). This is because CityGML offers the flexibility of supplementing the data model with domain specific object types and attributes, and therefore guarantees high degree of interoperability with other systems [8].

3 Cloud federation usage in the E&C sector

There is clear advantage of EU BIM as thematic module in CityGML technology in the generation and management of buildings digital representation of physical and functional characteristics. All this information creates an environment with shared knowledge resources, enabling decision-making support regarding the building. This covers all stages, from the earliest conceptual to the building design and construction, and even to its operational life.

In this environment, the cloud-computing paradigm provides on-demand services, creating new business models. Users in a transparent way pay according to pay-per-use constrains. Different providers using distributed and virtualized computing resources arrange these services. Small and medium companies can avoid making large investments of capital for purchasing their own IT infrastructure equipment. Instead, there is flexible and dynamic usage of services by virtualization technology decoupling applications from the physical machine, on which they run. Virtual Machines (VMs) migration technology provides with guarantee a concrete level of Quality of Service (QoS). Providers are able to supply different levels of service:

1. Infrastructure as a Service (IaaS),
2. Platform as a service (PaaS) and
3. Software as a Service (SaaS).

The cloud-computing ecosystem allows both large cloud providers, but also small ones to compete. Often the smaller ones use the mega-providers for developing their services. IaaS of cloud federation can be defined as an agreement between providers for the provision of virtual equipment. This equipment can include VMs, clusters, networks, etc. We need to have in mind that there is no strict and precise definition of design and implementation guidelines for the functionalities used to enable IaaS cloud federation. Thus, a requirement analysis for the definition of those characteristics and functionalities for an IaaS cloud federation is required. In addition, here follows, what we should focus on in applying cloud federation in E&C:

1. *ensure flexibility*: be able to work from different locations from construction site, to home, and office, and even on the move
2. *promote agility*: be able to use highly trained and up to date specialists, and services
3. *secure cost-efficiency*: use opex versus capex, and reduce both the upfront investments and the risks
4. *take advantage of scalability*: depending on the concrete E&C project go up and down to numbers, volumes etc.

Within E&C sector, there is a trend of organizations, of different sizes, adopting cloud technologies. They prefer to move their IT infrastructure from the traditional on premise server-based to the hosted, cloud-based IaaS cloud federation by using the internet to run applications, without own computer servers.

5 Conclusions

In this paper is presented a description of the current achievements regarding digitalization technologies in the engineering and constructions, together with concrete technologies like the CityGLM, BIM, and the EUBIMTG initiative. All these technologies create a huge capacity of gains for the constructions sector in all phases, and for all the actors, as constructions digitalization has a huge unexplored potential. The clear advantage of EU BIM as thematic module in CityGML technology in the generation and management of buildings digital representation of physical and functional characteristics was underlined. It was concluded that in this environment the cloud-computing paradigm provides on-demand services creating new business models. IaaS of cloud federation can solve many issues. The problem of lack of strict and precise definition of the design and implementation guidelines for the used functionalities used is identified. For the solution of the requirements analysis a four points list is proposed.

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References

1. Clarke, Keith. (1986). Advances in Geographic Information Systems. Computers, Environment and Urban Systems. 10. 175-184. 10.1016/0198-9715(86)90006-2.
2. Eastman, Charles; Fisher, David; Lafue, Gilles; Lividini, Joseph; Stoker, Douglas; Yessios, Christos (September 1974). An Outline of the Building Description System. Institute of Physical Planning, Carnegie-Mellon University. Retrieved from https://files.eric.ed.gov/fulltext/ED113833.pdf
3. EUBIMTG. (2017) Handbook for the introduction of Building Information Modelling by the European Public Sector, Retrieved from http://www.eubim.eu/handbook-selection/
4. Grieves, M. and J. Vickers. (2016) Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behaviour in Complex Systems, in Trans-Disciplinary Perspectives on System Complexity, F.-J. Kahlen, S. Flumerfelt, and A. Alves, Editors, Springer: Switzerland. p. 85-114
5. Martin Poljanšek (2017), Building Information Modelling (BIM) standardization. JRC Science Hub https://ec.europa.eu/jrc, Hermawan et al., (2016) Draws actors from the graphic, Institut Teknologi Bandung, Indonesia. Retrieved from https://ec.europa.eu/jrc/en/publication/building-information-modelling-bim-standardization ISBN 978-92-79-77206-1.
6. OGC City Geography Mark-up Language (CityGML) (2012), Encoding Standard, and External identifier of this OGC document: http://www.opengis.net/spec/citygml/2.0, Reference number of this OGC project document: OGC 12-019. Retrieved from https://portal.opengeospatial.org/files/?artifact_id=47842
7. Petrova-Antonova D., S. Ilieva, D. (2018-1). Future City: A pilot project of GATE Centre of Excellence. Serdica Journal of Computing, vol. 12, no. 1, 2018, ISSN 1314-7897.
8. Petrova-Antonova D., S. Ilieva, D. (2018-2). Smart Cities Evaluation – Survey of Performance and Sustainability Indicators. 44th EUROMICRO Conference on Software Engineering and Advanced Applications (SEAA), Prague, Czech Republic, August 29th - August 31st, 2018.
9. Virtual City Systems CityGML (2017), CityGLM Modularly structured based on OGC and Open Geodata Interoperability Specification (OGIS). retrieved from https://www.virtualcitysystems.de/en/solutions#citygml
10. World Economic Forum (2016), Shaping the Future of Construction: A Breakthrough in Mindset and Technology. Retrieved from http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report__.pdf