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Enterprise BIM: A Holistic Approach to the Future of Smart Buildings

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1 ABSTRACT

This paper presents Enterprise BIM (EBIM), which is the utilization of Building Information Modeling (BIM) in a holistic organizational aspect structure during the entire life cycle of a building. EBIM acts as a virtual comprehensive representation of the buildings and infrastructure that is aimed to optimize and improve business management, knowledge sharing, digital interaction and connection in the different phases of the building life cycle. This study shows how EBIM could support an organization's core business operationally and strategically. In fact, EBIM is aimed to support the building's entire life cycle and in this approach facility management (FM) is considered as a necessity. This paper demonstrates that FM is not a dedicated or a separate system and it uses exactly the same data as those required for business operations. Hence, we have surveyed the role of EBIM at St. Olavs Hospital as a case study for further consideration. St. Olavs Hospital uses EBIM to realize the goals of better and cheaper construction projects and real estate operations management with the aim of more efficient use of resources. The case study highlights the details and benefits of this approach both with respect to processes, tools and techniques. Furthermore, we demonstrate how EBIM may support interoperability, transparent communication and collaboration among the core business, facility management, the project organization and the different stakeholders throughout the building life cycle.

Keywords: Facility management, IFC, Model server, Enterprise BIM, BIM

2 INTRODUCTION

Digitization, if used wisely, provides a new and optimal way to view business structures and processes. The engineering and construction industry is one of the largest sectors of a country's economy, and real estate is a major economic challenge for any business. Therefore, the present study through describing EBIM as part of the business strategy for digitization, focuses on how to achieve optimum information sharing, collaboration, utilization and management of building-related data across disciplines and systems.

The building configuration and layout constitutes only a small part of the total body of useful information about a building. A really comprehensive and all-embracing building information model should cover and involve not only geometry and properties, but all the information about a building created during its life cycle and its relation to other systems and processes. The building information should be accessible to many different types of users — building owners, builders, operators, administrators, facility managers, portfolio managers and even emergency responders — via user interfaces that are available and approachable to each other (Smith and Tardif 2009). Principally, BIM aims to digitally represent the physical and functional features required to improve and document building designs. Today, BIM applications support walk-through visualizations, collision detection, energy performance estimation, heating-ventilating, air-conditioning systems, lighting design and the assessment of safety and generally issues related to security (Van der zwart 2014). A single building model creation is not only the proper and expected result of BIM; instead, the target is gathering and collecting comprehensive, accessible, reliable and readily exchangeable building information for everyone who requires it during the building lifetime. The value of distinct pieces of data — and with it, the commitment of different parties to compiling and preserving it — varies considerably during the building lifetime. Collecting and maintaining building information and history in a single storage for the whole lifetime of a building is useful and fruitful to individual users only insofar as it supports the many individual business processes during the lifespan. Building information modelling can potentially affect every aspect of business enterprises. Therefore, the implementation of BIM is recognized as an integral part of any business process, and not just as an isolated effort that only relates to a few specific tasks or projects (Smith and Tardif 2009).

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As will be discussed, while BIM is a method based on digitizing different parts of a building, EBIM focuses on all information management throughout the entire building lifecycle. This paper presents a study utilizing EBIM with St. Olavs Hospital as a case study. The EBIM concept obeys and follows the strategy of the openBIM standard during the building lifecycle and it is aimed to optimize and improve business management, knowledge sharing and digital interaction. Hence, the main objective of this study is to demonstrate how the EBIM can supports decision making during different phases of the building lifespan.

The Central Norway Regional Health Authority (HMN) is a state regional health enterprise that owns and operates hospitals. It consist of three hospitals, in total 700.000m2, where St. Olavs Hospital with approximately 350.000m2, is the biggest one. In 2012, St. Olavs Hospital, together with HMN initiated a project entitled Life Cycle BIM based on facility management. As a result, an EBIM philosophy was adapted where all buildings are an integral part in the entire portfolio of buildings, as well as the aspect structure defined in the hospital business structure. Using such a solution enables the integration of core business and the various processes of the hospital. Today EBIM is an extensive information database at St. Olavs Hospital and Central Norway Regional Health Authority that supports important aspects of the user, such as Facility Management (FM), Virtual Design Construction (VDC) and Property Management (Van der Zwart, Elkhuizen, and Evjen 2016). In this process, St. Olavs Hospital has pioneered using database technology to describe virtual building models according to the openBIM standard. The database is made up of many buildings which both old and new buildings have been incorporated in it. It implies that, the database should be kept updated during the decades of building lifetime and independent of proprietary data systems. The present study describes the transition from BIM to EBIM and indicates how EBIM is used as a digital platform to support building projects, facility management and core business of the enterprises.

3 FROM BIM TO EBIM

3.1 BIM and the Building Lifecycle

BIM acts as a transition of methods and technology from a single traditional consecutive form to a modern multiple parallel form of data integration. BIM is the procedure of data sharing and distribution with the capability to use the data via abundant applications for managing several multidimensional tasks and activities in architecture, engineering, construction, maintenance and different types of operation all along the building lifespan. In fact, utilizing BIM technology is essential for all sized enterprises which are active in the building construction industry and also it is inevitable and imperative for the companies who are seeking to enhance their levels of competitiveness and even their existence in the future cycle of the industry. To mitigate lacking productivity and efficiency in the building industry, BIM plays an efficient role to provide and offer the required information and precise data to be employed for model simulation in different phases in the building industry (Kouch, Illikainena, and Peräläa 2018). In fact, BIM stands at the core of digital transformation throughout the built environment and it provides a vital opportunity and pivotal role to develop and improve performance considerably in innovative ways of delivery and operation. It creates a collaborative method of working that facilitates early supply chain involvement, underpinned by the digital technologies which opens up more effective ways of designing, creating and maintaining assets and resources. It also provides a digital representation of the physical and functional characteristics of an asset to support reliable decisions and information management during its lifetime. For this purpose, at its core, BIM employs three-dimensional model and collective data to access and share information efficiently throughout the supply chain and increase the productivity and efficiency of activities and reduces the risk of errors and maximizes the team capability and potency to innovate (Leader: Cardiff University 2018).

Indeed, BIM makes virtual prototyping as a three-dimensional models and semantic representation of the building for better understanding and comprehension of the project and its components, by all the users and it can be used for the whole lifecycle of the building from the primary design and sketch to the construction, operation and maintenance phases (Lebègue et al. 2013).

3.2 BIM as a Facility Management Tool

Facility management (FM) is an organizational function that supports maintenance of buildings and their services during operation. As such, FM is a multifaceted, complex task that is often challenged by the lack of updated building information. The implementation of BIM can improve facility management tasks by providing related and appropriate data during the buildings operational period. BIM offers a platform for data exchange between stakeholders in the architectural, engineering and construction fields (Mohanta and Das 2016). However, as a result of rebuilding and partial replacements of building elements on a day-to day basis, FM is continuously faced with the challenge of updating the building information and its quality. Hence, it implies that the FM function may not provide reliable data to building owners for lifecycle management and continuous planning. Therefore, as a emerging technology, BIM is prepared for offering a new level of serviceability and operability to manage buildings and the physical assets in them. (Association 2013). This advantage is a direct result of being able to perform multiple analyses and generate the various documents required by the BIM and information will be more available through increasing the interoperability and collaboration process.

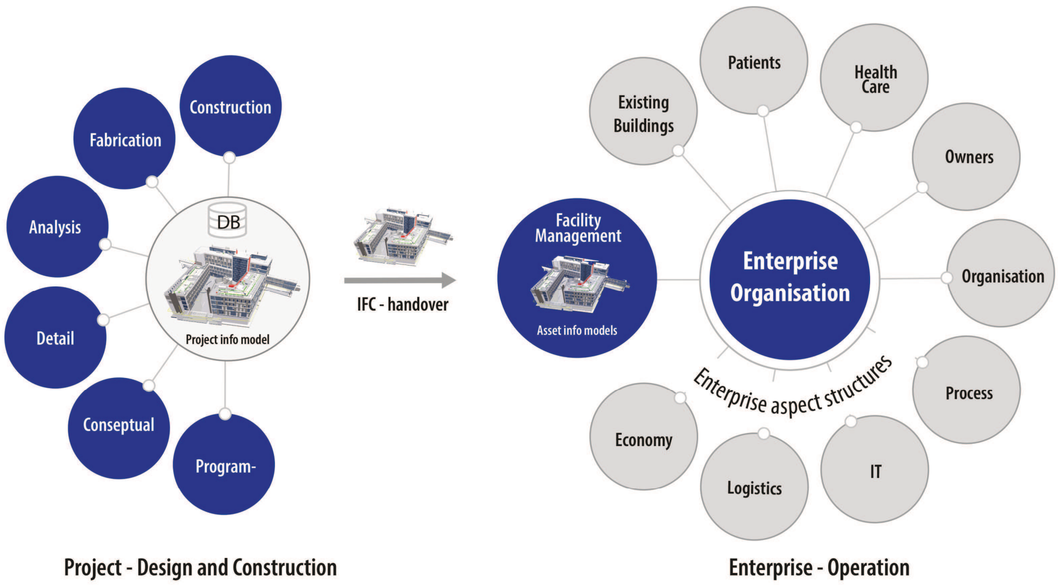

Fig. 1: Description of a classical "BIM-project". The project information model (PIM) developed during the design and construction phase of a project. The asset information model (AIM), IFC files, according to the specifications, are delivered to the Facility Management System.

BIM offers facility managers and building owners/operators a powerful means to retrieve information from a visually accurate, virtual model of a physical facility. BIM also strengthens interactive information improvement and development and has the ability and capability of supporting the full building lifespan from planning through operation and maintenance. However, BIM will not necessarily replace the wide range of information technologies in use by facilities and organizations but it can support, leverage, and enhance these technologies (Association 2013).

The common process for transferring BIM information developed in a building project to FM is illustrated in Fig. 1. The BIM model of a building project is created during the construction phase by applying a Computer Aided Design program (CAD) with product data from various product catalogues. The building owner has to specify the BIM requirements to ensure that the BIM model meets the specifications of the FM system and its applications. During the assignment, the building project exports the BIM model as IFC files as part of the BIM delivery specification to the FM organization. From this point forward, the FM organization is responsible for importing and implementing the IFC files and product documentation into its FM system. This corresponds to the outline of a traditional project delivery and the way of operation was applied before establishment of BIM. This way of organizing collaboration and handover has many difficulties that naturally prohibits the building owner, FM and the core business from participating in the development of the building project as a customer. The project is developed as a virtual building that is disconnected from the enterprise virtual environment and aspect structures such as economy, logistics, FM and IT organizational processes. Therefore, after handover, the customer is faced with conditions that causes significant problems related to insufficient and incorrect data for the operational phase. In addition, the as-built BIM lacks information related to the system tools and aspect structures applied during the building project. These are different from those in use by the enterprise. In addition, there are very few (if any) FM systems on the market that import BIM files for using in FM. As a matter of fact, most of current FM

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systems only replace traditional 2D/3D DWG files with 3D IFC files. This situation requires other solutions, which Enterprise BIM is an option.

3.3 Enterprise BIM (EBIM)

EBIM is based on the understanding that the world is three-dimensional, holistic, process-oriented and object-oriented. This means that both the real and the digital built environments with all objects and interrelated objects and processes are connected in a complex interlinked network, realized as an Authoritative Data Source (ADS) in a model server. ADS is defined as the repository or system that contains the cohesive set of data and features that are considered as the primary source for this information and it provides reliable, proper, and secure information to support a business process. BIM's major transition to EBIM involves processes and activities as integrated parts of the building's digital life cycle information along with the BIM model. The task of creating a holistic three-dimensional digital representation reflecting the real built environment is daunting and it can not be entirely realistic. EBIM simplifies and clarifies the inherent complexity by creating an enterprise specific aspect structure that is related to other enterprise aspect structures and all end-users, as shown in Fig 2a. As illustrated, this implies that EBIM contains three-dimensional geometrical data and other building information, which in turn are interrelated to other aspects structures, such as economy and facility management.

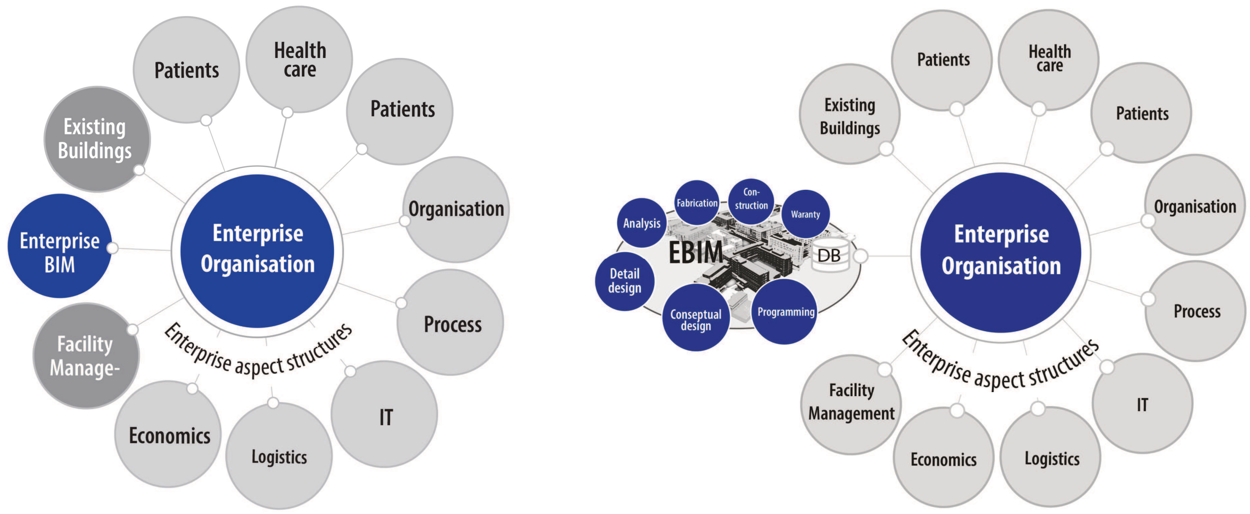

Fig. 2: Enterprise BIM as an authoritative data source aspect structure. a: EBIM is represented as a unique aspect structure in the organization. b:The illustration shows how a building project uses the same data infrastructure as the enterprise itself.

By treating EBIM as a business aspect structure for building information, and as a platform for open project integration with the organization, it is expected to lead to cost efficiency, customer satisfaction and prevention of data loss. EBIM is essential when rebuilding or when major renovation of the physical building requires round-trip of the digital building data. In most cases the builder, owner, managers or employees have little or no access to the BIM building project, despite the fact that the access potential of customers, users and operational organization to the virtual building in all phases of the project will have a major impact on quality, knowledge transfer and user interaction (Helse Midt-Norge 2017).

By considering EBIM as a digital interaction paradigm for all types of documents and properties through all building phases, where all users and stakeholders can initially share and obtain insight through different digital interfaces, the focus is shifted from the project-centric BIM to view EBIM from an enterprise perspective. One of the most important concepts of EBIM is emphasizing the integration, information sharing and openness across business structures that prevents vendor lock-in. Vendor lock-in occurs when a company becomes constrained and restricted due to its relies on a services provided by a vendor or builder. Fig. 2b shows an overall view of the concept and illustrates the relationship between the real building, EBIM and the building processes. In this concept, it means that all information is shared and EBIM reflects the real building complex as far as possible, regardless of phase (Helse Midt-Norge 2017). Collaborative design must support the sharing of data as knowledge rather than just the transfer of data as information in documents associated to business processes. Therefore, EBIM facilitates a new way of digital interaction and is an important step towards creating a future with smart buildings where the enterprise uses realtime simulation during the construction projects and in daily operation. As a case study, St. Olavs Hospital has established an organization and a technology platform that supports this approach.

4 ENTERPRISE BIM AT ST. OLAVS HOSPITAL

St Olavs Hospital is an integrated university hospital, which means that Faculty of Medicine and Health is located all over the hospital. The hospital provides leading clinical care for Mid-Norway and is organized in a center model, which divides the hospital layout into seven distinct units around an open square (Van der zwart, Elkhuizen, and Evjen 2016). As already stated, St. Olavs Hospital encompasses of many buildings, both old and new, which should be maintained during their several decades of life cycle. Accordingly, a homogeneous standardized open digital platform for developing, improving and maintaining their facilities and amenities efficiently (Øgård Aksnes 2016).

The project life-cycle BIM, established in 2012, aimed for creating a real life-cycle BIM based on a facility management platform of existing buildings (Kristian Jørstad 2017). The EBIM philosophy established during the project, builds on a model server, where each old, new, and future building are integral units in the overall portfolio of buildings (Van der Zwart and Evjen, n.d.). The platform incorporates all old and new buildings, with existing documentation, lease management and work orders from the previous FM system, in a openBIM database platform (Kristian Jørstad 2017). This requires that the health care institution must have full ownership and control of all building-related information throughout the building life cycle, from early phase to demolition. The most important aspect of employing EBIM is the concept that EBIM virtually represents the real buildings, at a sufficiently detailed level and quality, and the relationships with the various stakeholders (Monsen 2017). It also defines which stakeholders can benefit from the information contained in the model. St. Olavs Hospital applied the following definition for EBIM: „EBIM is a virtual holistic representation of buildings adapted for optimized business management, knowledge sharing and collaboration“.

Fig. 3 outlines how stakeholders are related to each other and the physical buildings which are linked again to the virtual environment through the sensors. An important factor in the ownership of the virtual built environment is that the owner of the building must have the knowledge and tools to assist and control properly the entire digital process (EBIM IT).

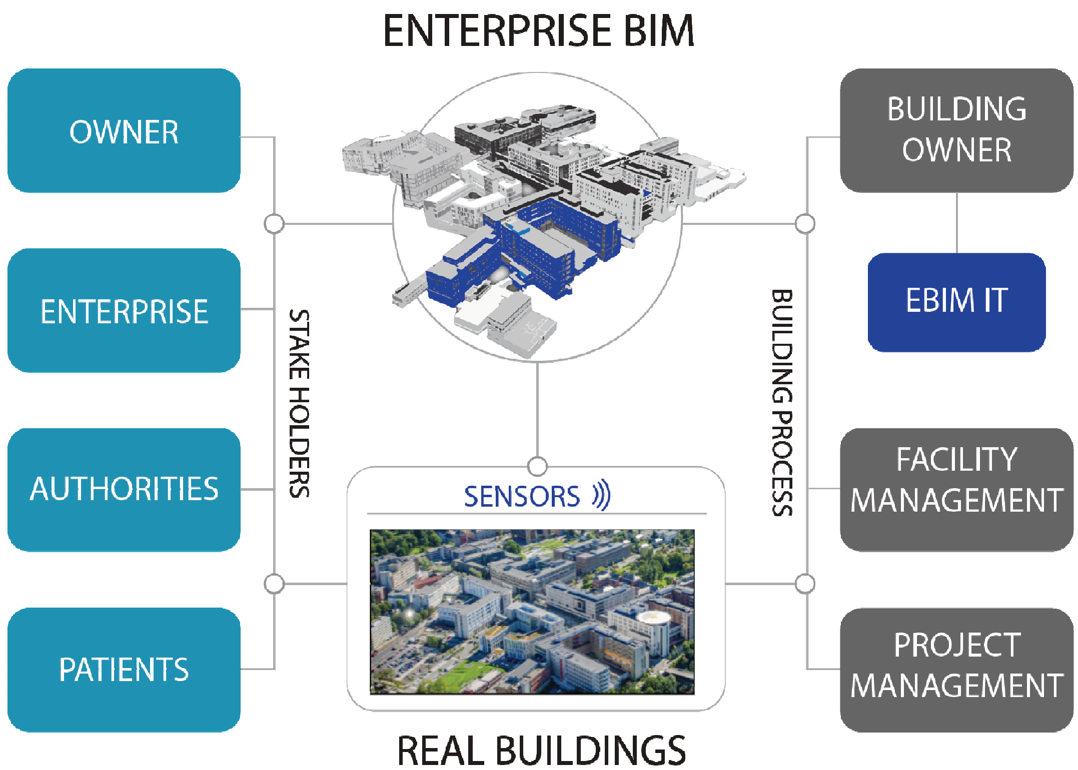

Fig 3: EBIM stakeholders. The relationship between the real building, EBIM and the actors are indicated.

EBIM is a virtual environment with a common data sharing repository where all stakeholders share and collaborate on the same data in real time.

St. Olav Hospital currently uses EBIM to realize the goals of better and cheaper construction projects and real estate operations management with the aim of more efficient use of resources. Buildings where EBIM is used throughout the process have a better quality of operation and maintenance and they offer a higher level of service for employees and visitors than buildings that have been designed and built traditionally. In this respect, other advantages are proper functionality, easy benchmarking against other projects, faster execution, fewer construction errors, cost reduction, reduced energy consumption and carbon footprint, harmonizing and streamlining of operations (Helse Midt-Norge 2017).

Technically, the model server with all building-related data and embedded systems, shown in Fig. 4, is referred to as the EBIM aspect structure. When the BIM server imports new IFC files and documents from a construction project, the IFC files are validated by the BIM server according to given rules, in such a way that the building owner receives the virtual building model at specified level of detail and quality. In addition, the documentation is also checked against the existing infrastructure of the model server to be compatible with the EBIM aspect structure and internal classification.

EBIM replaces traditional facility management systems through featuring functionality supporting operation, management and maintenance. The end user interface is a web-based real estate portal tailored for the end user disciplines. Moreover, the connection between the three-dimensional models and the sensors and transmitters in the buildings enables and facilitates tracking and retrieval of mobile equipment and people, among other things (Lien and Evjen 2017).

Communication with other aspect structures and systems are primarily done through application protocol interfaces (API). A simple example of such integration, are printers that are used to label patients medications. In this case, the information is held digitally by the IT database, but the printers locations are displayed on the real estate portal. This is a small example of minor improvements in the functional efficiency of daily hospital work.

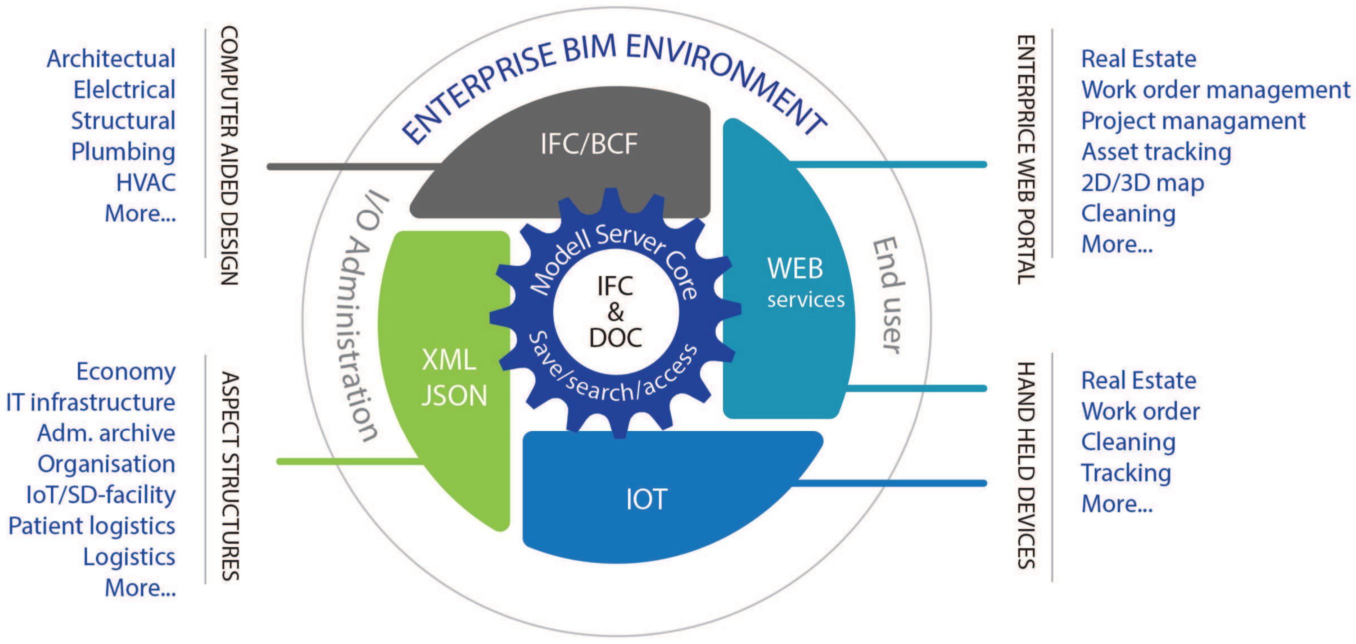

Fig 4: Schematic image of a model server that supports EBIM aspect structure, Web-based real estate portal, wireless and handheld devices.

A model server in itself is a complex digital environment, but the model server client gives the professional staff almost free access to configure and develop new functionality and applications, as shown in Fig. 5. In a hospital with many computer systems, abundance of data and the continuous need for improving and supporting daily routines, a flexible database solution is essential. One of the most complex and challenging tasks is maintaining an existing digital building while different parts of the building are being rebuilt.

Fig 5: The model server consists of a collection of integrated BIM models with property sets, documents, methods for evaluating and checking the models and other turn key functions.

The following two figures show examples of functionality presented to the hospital through the real estate portal. Fig 6 presents a report page where all employees at the hospital can report and follow the status of various working orders from requested repair of a broken door to application for additional space for specific functions. The user only navigates through the map and selects rooms or objects in a 2D/3D map to identify the rooms or objects for the selected task. By entering the data of interest, a work order will be established and submitted to support the designated facility management staff who will execute the work order with all related data. The work order itself is connected directly to the specific rooms or objects in the model server.

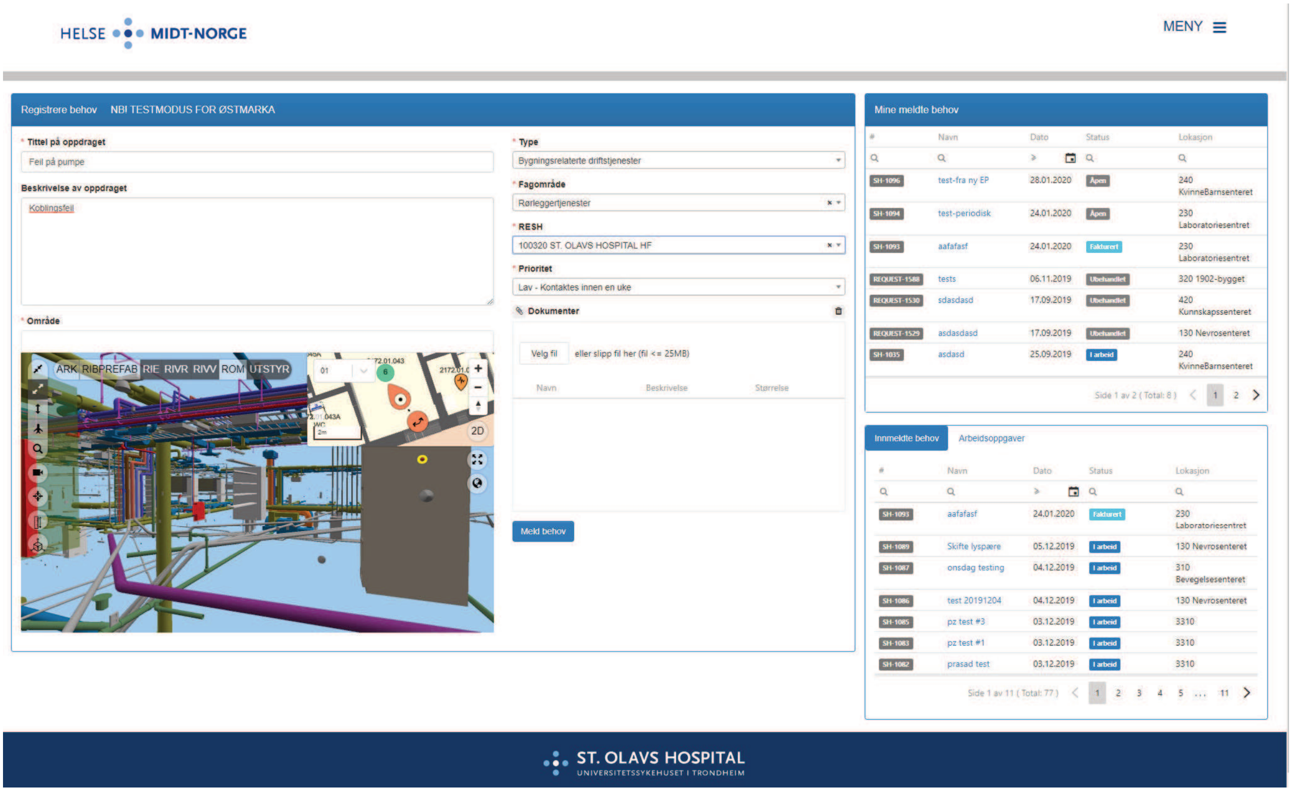

Fig. 6: A snapshot from the real estate portal showing the interface presented for the staff at the hospital for reporting and following up a work order.

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Fig 7 displays a 2D view map which demonstrates how the real estate portal presents, in color, different types of room functions in the buildings based on the hospital classification system. The same web page can be used to display rental agreements related to a room.

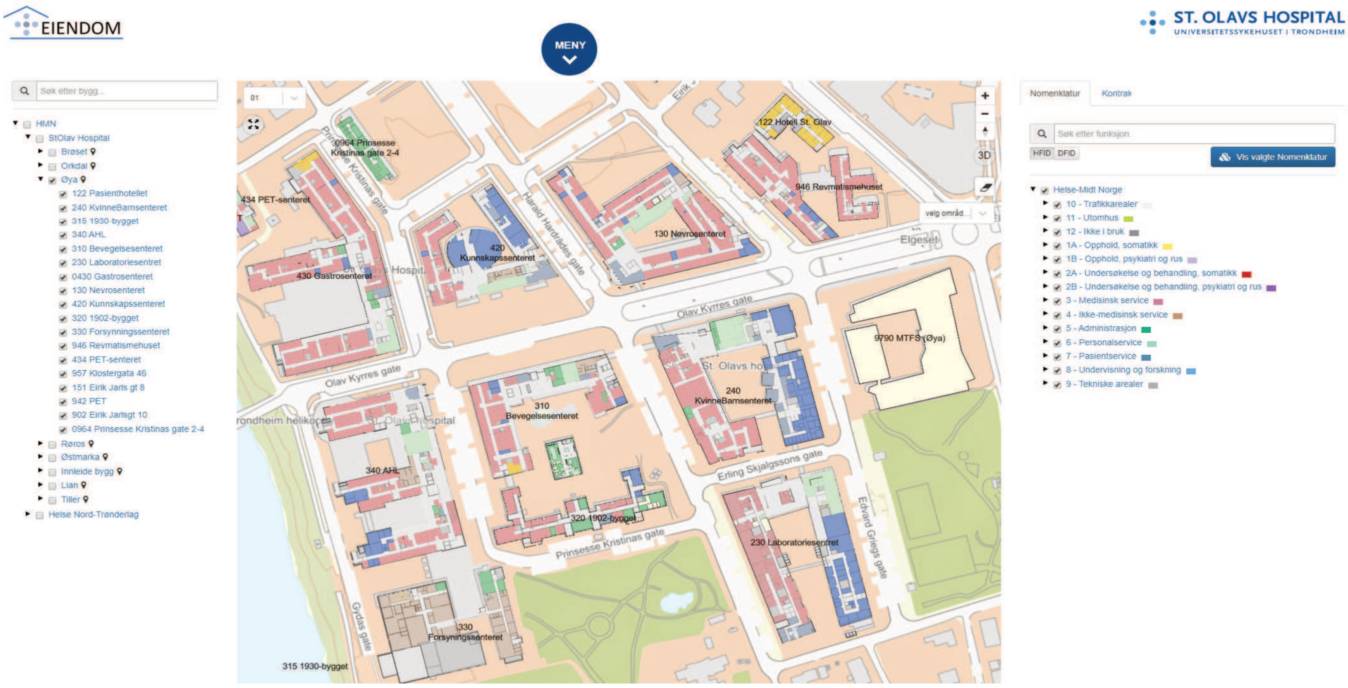

Fig. 7: Visualization of all partial functions in a set of buildings. The different functions are color-coded. Their distribution across the wing and floor is clearly visible throughout the facilities.

5 DISCUSSION AND PERSPECTIVES

As previously noted, EBIM is an extensive information database at St. Olavs Hospital that supports important aspects for the user, including FM, Virtual Design Construction (VDC), tracking and property management. EBIM facilitates essential and major tasks of the core business and is an important source for strategic management analysis in the near future (Øgård Aksnes 2016). In addition, central operations monitoring and sensor technology support EBIM to be more knowledge based. These tools have a significant role in decision making, object tracking, optimizing inventory space and operational costs (Van der Zwart and Evjen, n.d.). In this regard, a common basic information functionality for handheld devices, VR and Web, has been established in St. Olavs Hospital but they are still in the beginning of robotization and automation based on EBIM.

However, the hospital's EBIM platform does not support a user-friendly process modeling tool that supports project planning and other types of workflow.Even though, work order workflow is fully implemented and gantt charts are realized as part of the periodic maintenance, the EBIM platform lacks important and powerful functionality to claim to be a knowledge-based system that supports project planning in full detail with reflective views, roles and tasks (Lillehagen and Krogstie 2008).The implementation of EBIM at St. Olavs Hospital is still in its infancy. The advantage of using a model server based on openBIM standard to obtain all the building data and the capability to develop new functionality is a major competitive advantage, especially for an enterprise of a certain size. New applications and connection to other aspect structure systems are under development. The complexity and the pure size of the data collected makes it necessary to start using technologies like Augmented Reality (AR) to discriminate data in order to provide accurate data delivery to the end user and to apply Artificial Intelligence (AI) to process data.

In fact, the approach and strategy of EBIM is built on its use in organizational processes in the course of the whole building's lifecycle where all buildings will be described and communicated in openBIM standards in relation to other business aspect structures (Lien and Evjen 2017). openBIM is built on workflows and open standards which are used to gain collaborative design, performance and operation of buildings(Øgård Aksnes 2016). Thus, openBIM supports a transparent and open workflow and permits stakeholders and users to take part in and join the project regardless of their software tools. It permits government and industry to obtain projects with transparent business interaction, ensured data quality and Service evaluation by establishing a common language for extensively referenced processes. (Graphisoft - A part of the Nemetschek Group, n.d.).

The beneficiaries include the owners, managers, users of buildings and all actors that are involved in the project (Kristian Jørstad 2017). Therefore, it expects to achieve EBIM for a better decision based on strategic management, user participation and implementation at all levels. It strives also to get transparent communication and knowledge sharing across the organizational structure (Monsen 2017). Hence, EBIM provides unique opportunities for users as a business to use the available information to manage, operate and develop the buildings throughout their lifetime. The projects must support the business by providing correct information during the planning and construction. Therefore, the projects will be organized so that all relevant information flows to and from the model server. In practice, it is said that the project organization with advisors and contractors will save and develop data (including documents) in the model server.

Introducing new technology that challenges data ownership, existing systems, collaboration, efficiency change, new way of working and motivating to achieve a greater goal, is what that needs to be greatly motivated by the enterprises and organization related to these processes. In this regard, St. Olavs Hospital has a strong focus on how EBIM can support its core business operationally and strategically. At the national level, EBIM supports government and other enterprises in real-time monitoring of demand through web services and it avoids unnecessary reporting and data replication.

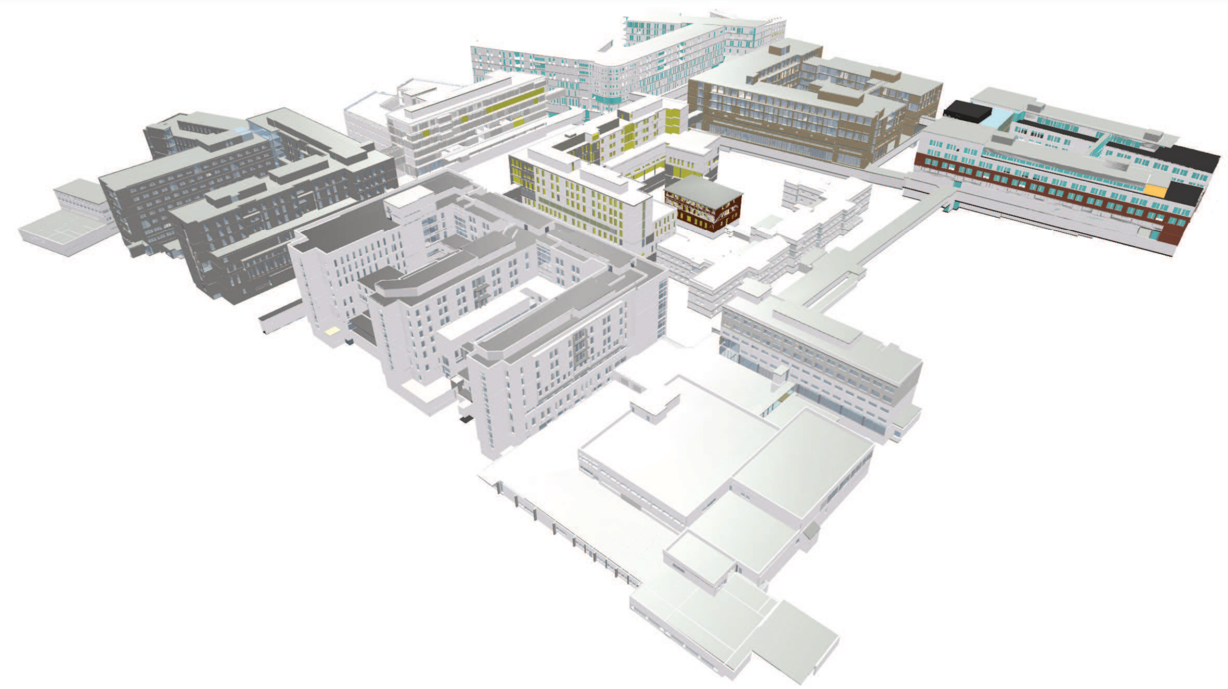

Fig 8: St Olav’s hospital site with 220.000 m² – Image taken from EBIM system.

6 CONCLUSION

EBIM obeys and follows the strategy in which all buildings and infrastructure in an enterprise are described and communicated in a uniform openBIM standard during the building lifecycle. EBIM seeks to establish clear and transparent communication and knowledge sharing throughout all organizational structures. Using the EBIM method, the traditional boundaries between project and owner are eliminated by the way in which, the owner implements the project into the digital platform of the enterprise and not as a single standalone building project. This ensures rational and logical digital management of buildings which can reflect engineering structures, performance of buildings and infrastructure from registered demand to demolition. Accordingly, by using EBIM approach, St. Olavs Hospital establishes a virtual building information structure that is capable to support day-to-day maintenance, tracking objects and providing different views to the end user. The work done at St. Olavs Hospital is based on anticipated benefits and so far there is clear evidence of improved data quality and new approaches are emerging. The next step in the advancement of EBIM is to establish additional abilities and capabilities that support the projects in their development towards complete construction in relation to the enterprise aspect structures in real time. EBIM has the potential to become the next step in the process of building business-centric smart buildings that reflects and support the real-world processes, games, social interaction and knowledge sharing across all enterprise disciplines.

7 ACKNOWLEDGEMENT

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