

The logo for BIM Exchange features the letters 'BIM' in a large, bold, orange sans-serif font. Above the 'i' and 'M' are three small orange circles. Below 'BIM' is the word 'EXCHANGE' in a smaller, grey, all-caps sans-serif font.

# BIM EXCHANGE

**Mitra Innovation Leverages WSO2's  
Open Source Middleware to Build  
BIM Exchange Platform**



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## Contents

1. Introduction .....	3
2. What is BIM.....	3
2.1. History of BIM .....	3
2.2. Why Implement BIM .....	4
2.3. Industry Foundation Classes (IFC) .....	4
2.4. The CIO's Challenge with BIM .....	5
3. BIM Exchange .....	5
3.1. Overview of BIM Exchange Platform.....	6
3.2. BIM Exchange High Level Architecture.....	8
3.2.1. BIM Exchange API.....	9
3.2.2. BIM Exchange User Portal .....	11
3.2.3. BIM Exchange Admin Console.....	11
4. References .....	11
5. Conclusion.....	12

## 1. Introduction

This white paper aims to provide a complete understanding of BIM Exchange platform developed by Mitra Innovation. Building Information Modeling (BIM), is now becoming a standard, adopted by many companies in the AEC industry. Software vendors are in the process of enabling BIM compatibility into their software to support standards demanded by companies and regularities. While many stakeholders involved in a large BIM project exchanging information, lack of integration, governance and visibility of information could lead to many complexities. To address these issues, Mitra Innovation has developed a lightweight, robust, scalable and extendable platform called BIM Exchange using open source products.

BIM Exchange enables disparate software applications used in a large BIM project to exchange information seamlessly. It provides a rich API, where legacy applications could be easily integrated. Architects, engineers, contractors and project managers could now exchange, composed and aggregated model information through BIM Exchange which gives them the clear visibility of the project. This is done via exchanging information with BIM compatible IFC files through BIM Exchange. More information about IFC could be found in the section 2.3 of this document.

BIM Exchange was developed based on two main software platforms. In order to achieve the capabilities of integration, managed APIs, security and scalability, open source WSO2 middleware platform is used. To provide all BIM related capabilities, BIMserver platform is used. More information about these platforms will be discussed in the sections to follow.

## 2. What is BIM

Building information modeling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of places. The US National Building Information Model Standard Project Committee has the following definition:

*“Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition”*

As the name suggests, BIM was originally conceived for use in the lifecycle management of buildings. However, the philosophy, approach and methodology is equally applicable to other similar areas, e.g. transport infrastructure such as Highways, Railways, Ports and Airports.

### 2.1. History of BIM

Historically, the construction industry has operated from 2D drawings, produced in proprietary software packages. This has created inefficiencies in the supply chain when information sharing is required.

Many organisations around the world have realised that there is the potential to transform this aspect of their infrastructure supply chain through the introduction of standard information

models, leading to the creation of BIM standards. For example, in June 2011 the UK government published its BIM strategy, announcing its intention to require collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on all its projects by 2016. In so doing, it predicts lower costs, faster delivery, lower emissions and improvements in exports to position the UK at the forefront of international construction.

Some solution vendors and early adopters refer to BIM as a “6-dimensional solution”, whereby in addition to the usual 3D spatial model, the further dimensions represent schedule, cost and in-life / facilities management.

An April 2015 survey of 1,000 UK construction professionals revealed that BIM adoption had increased from 13% in 2010 to 48% in 2014.

## 2.2. Why Implement BIM

Many public sector organisations around the world have mandated BIM adoption for all future projects from 2016. Therefore, for many organisations, BIM adoption is a necessity, not an option. That said, there are compelling reasons for adoption, in addition to client demand, including:

- Having a common “one truth” digital model for buildings or infrastructure
- Simplified interoperability in multi-organisation projects
- Reduced costs for information lifecycle management

Earlier identification of design & build issues, leading to faster, lower-cost resolution.

## 2.3. Industry Foundation Classes (IFC)

Model information of a BIM project is submitted to BIM Exchange using IFC files. Industry Foundation Classes, as known as IFC, is an object-based file format with a data model developed by “buildingSmart”. It is an open file format which is not controlled by a vendor or a group of vendors. It is also an ISO registered standard under ISO: 16739:2013 standard. The initial version of IFC (IFC 1.5) was released on 1997 and the current version, IFC4 was release in year 2013.

There are 3 IFC file formats currently defined, which is supported by BIM Exchange.

- IFC-SPF is a text format defined by ISO 10303-21 (“STEP-File”), where each line typically consists of a single object record, and having file extension “.ifc”. This is the most widely used IFC format, having the advantage of compact size yet readable text.
- FC-XML is an XML format defined by ISO 10303-28 (“STEP-XML”), having file extension “.ifcXML”. This format is suitable for interoperability with XML tools and exchanging partial building models. Due to the large size of typical building models, this format is less common in practice.
- IFC-ZIP is a ZIP compressed format consisting of an embedded IFC-SPF file and having file extension “.ifcZIP”.

More information of IFC specification could be found in the reference section of this document.

#### 2.4. The CIO's Challenge with BIM

Of paramount importance to the CIO is ensuring all those involved in projects have access to the BIM project data. This includes subcontractors and others in the supply chain who may not be employees of the organisation or have access to the intranet, or other enterprise content management system.

Given the very large data volumes typically associated with BIM projects, there can also be challenges around system performance, scalability and availability. Many organisations are opting for cloud-based storage solutions as a cost-effective means of addressing these challenges.

BIM adoption is still at a relatively early stage, with a long way to go until it is ubiquitously used. For this reason, there can be shortages of suitably skilled staff to oversee the implementation. This in turn leads many early adopters of BIM to select an outsourcing and/or partnership model as a means of mitigating this risk.

Finally, the CIO must step up to assist the organisation with operating in a mixed environment where some infrastructure projects are BIM compliant, and others are not. Typically this means accessing data from legacy non-BIM compliant GIS, CAD and asset management systems. Given the significant investment in non-BIM compliant legacy systems within many organisations, this final challenge is seen by many to be inevitable for some years to come. An enduring, flexible, scalable cost-effective solution is therefore required.

### 3. BIM Exchange

As introduced above BIM Exchange is a software platform developed by Mitra Innovation using open source platforms such as WSO2 middleware and BIMserver. Primary objective of BIM Exchange is to provide a vendor neutral BIM information exchange platform which is lightweight, scalable, extendable and cost effective. Irrespective of software used in a BIM project by different stakeholders, BIM Exchange provides a highly sophisticated integration engine to connect them. This allows those legacy applications to be BIM compatible immediately without going through expensive changes.

When a BIM project is created in the BIM Exchange all stake holders of the project (design team architects, engineers in the construction team, project managers, asset managers, risk managers, project owners) will be able to use the platform in their interest. The rich API of BIM Exchange allow secured access to model information published by stakeholders. Each project team could have their own sub project, which will be governed by the main BIM project in the BIM Exchange. Usage of BIM Exchange could vary, depending on the team it is used. Some may use only the BIM Exchange API to integrate it to their applications while others may use the BIM Exchange dashboards to perform analytics, identify collisions, view merged 3D model etc. Each team could be configured using different security policies to control access to the BIM Project. The BIM Exchange administrator has the universal access for all the sub projects and information. *Figure1* below depicts how BIM Exchange is used by different stakeholders of a large BIM project.

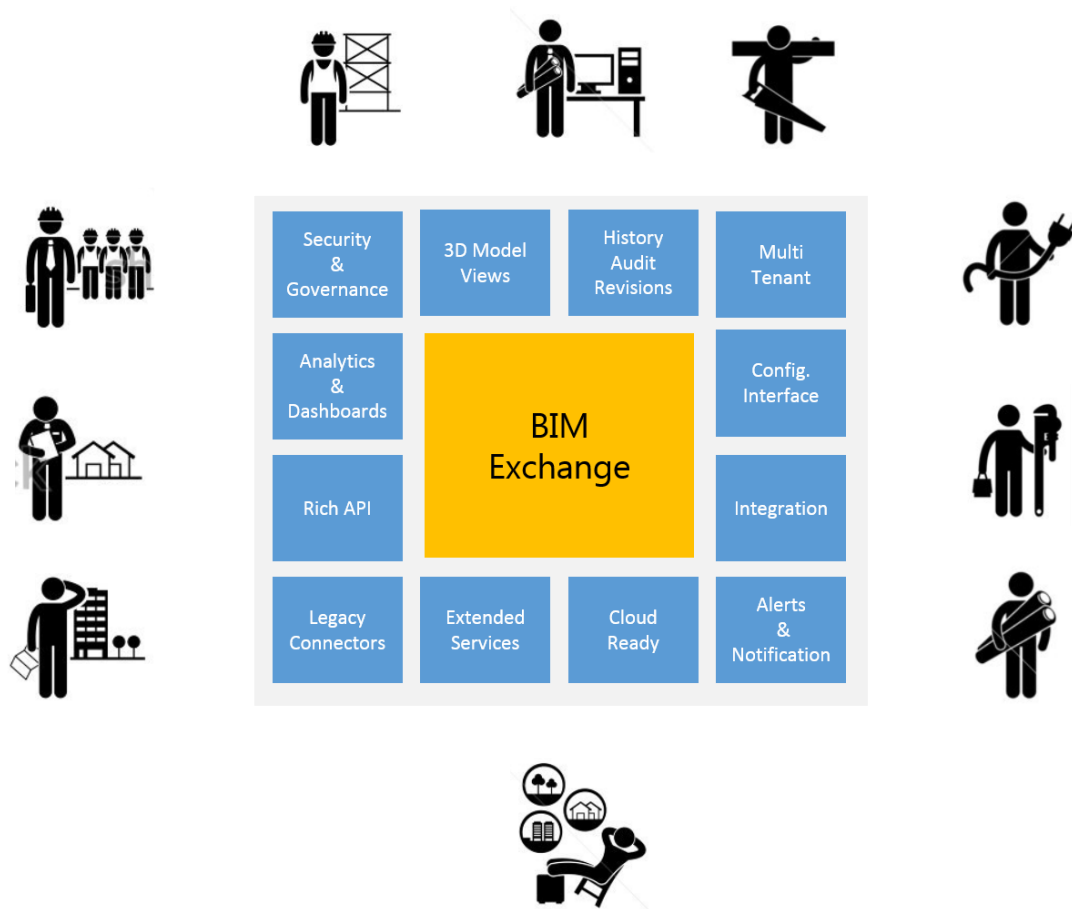


Figure 1

### 3.1. Overview of BIM Exchange Platform

The BIM Exchange platform provides a framework to perform many different tasks in a BIM project effectively.

The stakeholder of a BIM project could be from disparate locations, different companies working together as a single team. Access to information securely becomes crucial in such an environment. BIM Exchange leverages on the underlying powerful identity management capability of WSO2 Identity Server to manage the security of BIM Exchange. The API access could be controlled by different user stores for each team or company. It could be the local active directory of the company or a custom access control list. The advantage here is, BIM Exchange does not need to manage user authentication or authorization, and instead it could delegate this to different security providers and manage them centrally.

BIM Exchange API is a powerful BIM based functionality exposed to the project team. This API provide rich functionary of accepting IFC files which contain the model information, validating and checking of models, merging models and trigger event to perform different actions based on IFC submissions. BIM Exchange API is described in detail in the section 3.2.

Integration is a core capability of BIM Exchange. When working with disparate systems, teams would always face challenges with information being exchange accurately. BIM Exchange leverages on underlying WSO2 Enterprise Service Bus to provide seamless integration between

applications. The information is not necessarily has to be BIM related. For example, legal team may need to automate the submission of building plan information to a certain authority who provides an electronic lodgment interface. With the integration capability, these kinds of tasks could be easily automated.

BIM Exchange could be configured easily with the browser based configuration interface. Context specific help will guide the administrators to configure and manage all the components BIM Exchange in a single administrative console.

Connecting legacy applications to BIM Exchange made easy with the legacy connector interface. Connectors could be developed to read information from legacy applications, transform data IFC specification and persist to BIM Exchange. Data could then take part in BIM functionalities along with related models. When retrieving information, connector could convert IFC information to match the legacy application format. Legacy connectors are developed in a pluggable manner, so the BIM Exchange users could leverage on existing connectors developed for BIM Exchange. Each connector is plugged in to the ESB to provide seamless data exchange.

Third party vendors provide different service interfaces to perform BIM related functionalities. These services could be easily integrated to BIM Exchange via the extended services. They could be then used in a BIM project with a trigger to execute it when IFC data is submitted to BIM Exchange. For example, consider a vendor who provides a service to read an IFC file and output an Excel file with IFC model schedule report. This service could be configured with the extended service interface and trigger to execute whenever an IFC file is submitted to BIM Exchange. The generated report is delivered back to the BIM Exchange from the vendor service making it available to the project team.

Model data collected overtime stored in the BIM Exchange could be used for analytics. Underlying WSO2 middleware platform of BIM Exchange provides the capability of collection of data, and provide intelligence and operational analytics. Using technologies such as Hadoop MapReduce and Hive, Business Activity Monitor of WSO2 adds a great value to BIM Exchange platform. In order to visualize analytical data, WSO2 User Engagement Server provides the out of the box capability for end users to create their own dashboards and share them among the team with necessary security permissions.

The models submitted to BIM Exchange contains the geometric model data that could be visualized with three dimensional views. The underlying BIMServer uses “bimvie.ws” plugging to bring the capability of evaluating and analyzing the 3D models of the project in a single view. When multiple project work on different aspects of the project with various 3D models, BIM Exchange allow them to merge those views and provide a composite 3D view of the project.

BIM Exchange manages different revisions of the models submitted by the project teams. This allows the users to see the bigger picture on how the model had been evolved overtime. The capability of loading the 3D model from past revisions and execute functionalities on those models gives a great insight to the project team. BIM Exchange keeps track on all the changes to the model. It also keeps track on the user activities exposing it as an audit information when needed.

BIM Exchange is cloud ready. It could be deployed to private, public and hybrid clouds enabling the platform to run on premise and cloud. An on premise deployment of BIM Exchange will not need any re-architecting effort when moving to cloud due to this reason. BIM Exchange is multi-

tenant enabled by default as a BIM project involve many stakeholders from various project teams when running concurrent projects. With necessary permissions, teams who are in different projects will be able to access the functionality of BIM Exchange with a single deployment.

### 3.2. BIM Exchange High Level Architecture

As explained in the above section, BIM Exchange run on top of two main foundation platforms.

- WSO2 Middleware Platform to provide the integration capability, security, API Management, extendibility and the scalability of the BIM Exchange. While this is the primary usage, BIM Exchange also leverage on the other out of the box capabilities provided by the WSO2 platform such as dashboards and analytics.
- BIMserver platform to provide the complete BIM functionalities such as model manipulation, three dimensional analysis, model merging capability, model checking and validations capability and more.

Below *figure2* depicts the high level architecture of the BIM Exchange.



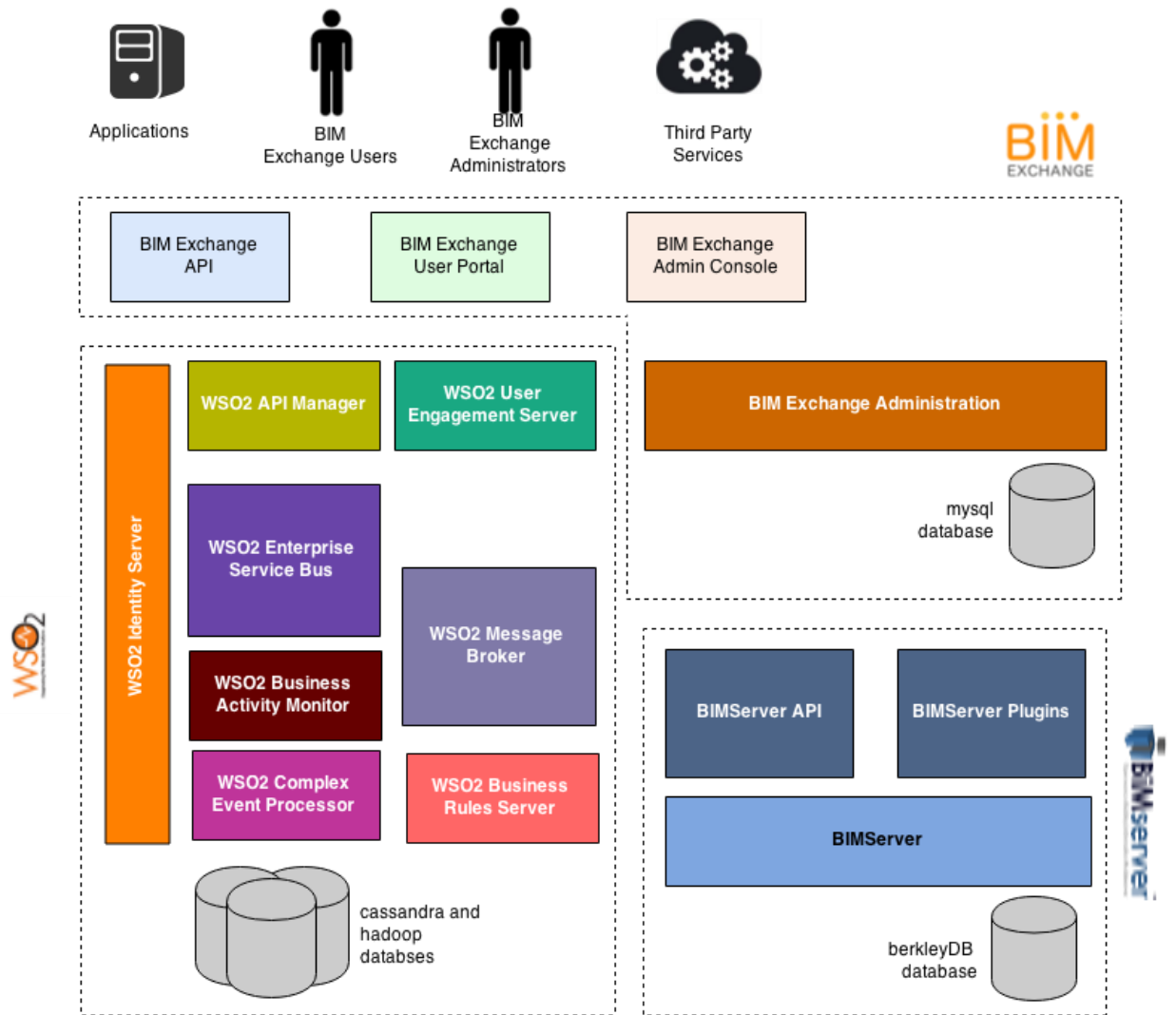


Figure 2

### 3.2.1. BIM Exchange API

BIM Exchange API provides a rich set of BIM related functionality. It is offered as a RESTful API communicating with a JSON payload. The functionality offered in BIMServer is wrapped into a proxy API and published via the API Publisher with required security QOS settings to the API Store. End user applications subscribe to this API and receive the API consumer keys and secrets to invoke the API which supports OAuth 2.0 model. When the proxy API is invoked, the authorization will be handled by WSO2 identify Server based on the security settings of the proxy API.

BIM functionality involves processing of large IFC files. When a BIM project is created in the BIM Exchange, IFC files are submitted against the project. In a large BIM project multiple teams may perform IFC file check in manually or via applications. In case of a legacy application, it could be a different file format getting checked in, resulting a legacy convertor to convert it to IFC format. All these operations are resource consuming operations and

could cause performance impact. Therefore, all BIM API functions are developed in asynchronous nature.

In the below scenario (*figure 3*), API for check in an IFC file is elaborated. All the APIs in the BIM Exchange follow the same execution pattern.

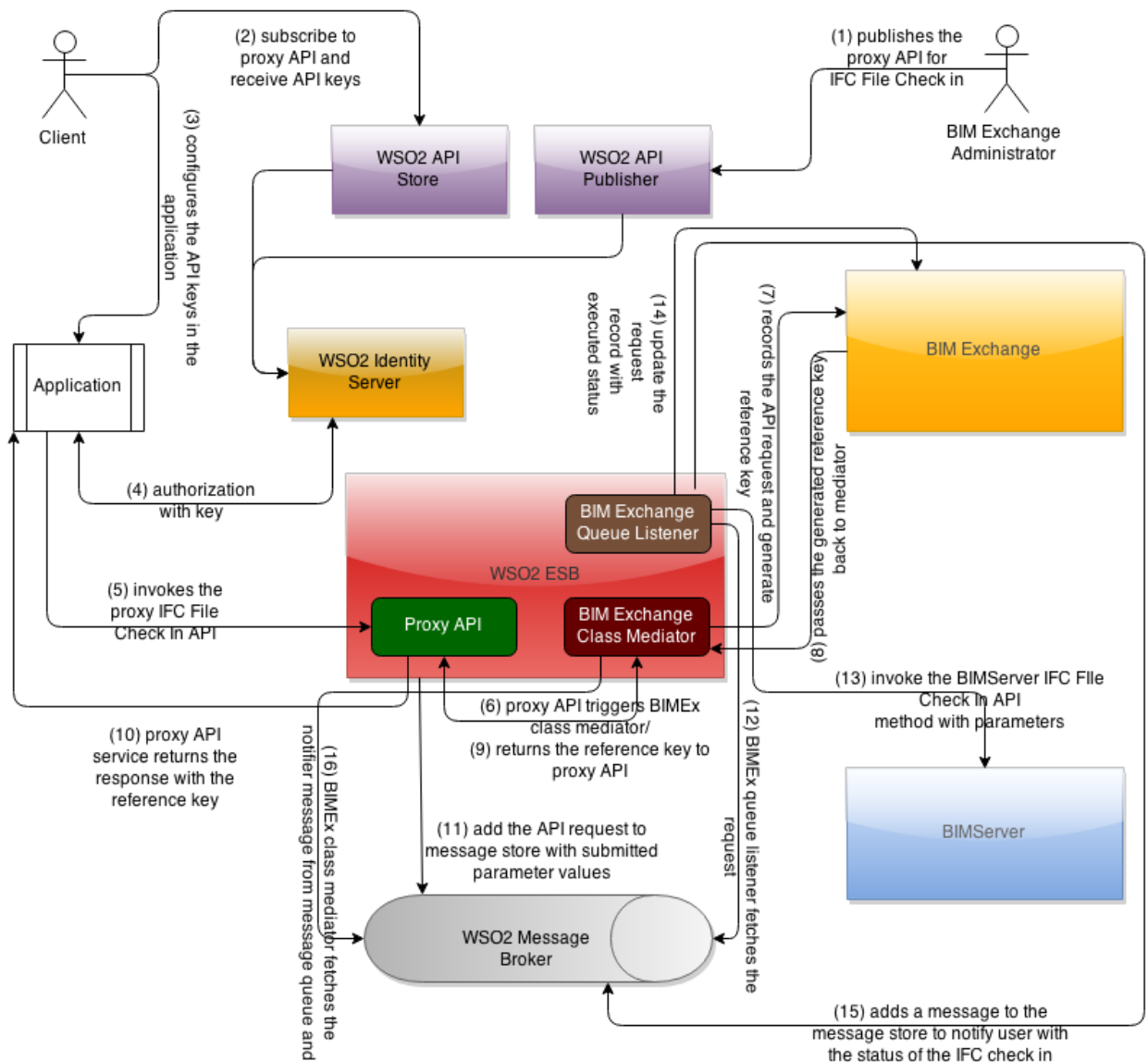


Figure 3

When the IFC file check in API functionality is published using the WSO2 API publisher, end users could subscribe to it via the API store through a predefined workflow. Client applications could then be configured with the consumer key and secret received by the API store. In this case, the client application could be a CAD software that generates IFC files for an architectural model. Whenever the model is updated in the CAD application, it is pushed to the BIM Exchange using the API.

CAD application calls the proxy API by providing the project information, user information, API keys, application ID and the IFC file in JSON format. The call is first authorized by the WSO2 Identify stored based on the configured user store. Upon successful authorization, proxy API calls a mediator in WSO2 ESB that handled BIM Exchange API request management to generate a reference for the request. This reference then passed back as the API response to the calling application. Meanwhile the request will be added to a persistent message store for processing. WSO2 Message Broker is used for this purpose. When the request is added to the queue, a queue listener in the ESB reads the request, and invoke the relevant API in the BIMServer. For each activity an audit trail is created.

### 3.2.2. BIM Exchange User Portal

BIM Exchange user portal is a customizable, web based interface for the project teams. Access to this portal is controlled by the WSO2 Identity Server. WSO2 User Engagement Server is used to provide the functionality for the portal. There are built in functionalities of the portal.

- Project Board: Provides a list of projects that could be accessed by the current user logged into the portal. With the project board, user can view his project, other sub projects authorized, 3D models for the project, model information etc.
- Model Query interface: Project model can be queries to filter different elements of a project using a query language known as BIMQL. It's SQL like queries can be executed with this interface.

Many other interfaces could be developed based on the stakeholder need. WSO2 UES comes with the capability of creating dashboard, gadgets. Analytical data could be visualized via these dashboards by providing great insights to the project team.

### 3.2.3. BIM Exchange Admin Console

Admin Console of BIM Exchange provide the configuration of the platform. It is used to configure the underlying platforms as well. For the WSO2 components, Admin Console shall redirects the administrator to the respective administrative interface for each component. BIMServer administration is exposed via an API, hence the BIM Exchange wraps this functionality to a user interface. Access to the BIM Exchange Admin Console is also managed by the WSO2 Identity Server. It also offers the modules such as audit logs and history. BIM Exchange Admin capability is available through secure API's which allow for automation.

## 4. References

Following are the references for the components/tools/concepts used in this document.

- WSO2 Middleware Platform : <http://wso2.com/>
- BIMServer : <http://bimserver.org/>
- IFC Specification : <http://www.buildingsmart-tech.org/>
- BIM Query Language : <http://bimql.org/>

## 5. Conclusion

BIM Exchange is a software platform with a very rich set of middleware components. It's bundled with BIM capability that could be used out of the box. Not every component may suit every deployment but it is mature and sophisticated enough to use in a large BIM enabled construction and infrastructure projects. With the middleware platform, it is capable of performing even non-BIM related integrations, API Management and much more.

Mitra Innovation team is competent to look at your next BIM project and advice you how to implement BIM Exchange and provide you with a higher ROI, reduced waste of resources, accurate simulations of the project even before it starts and many more.