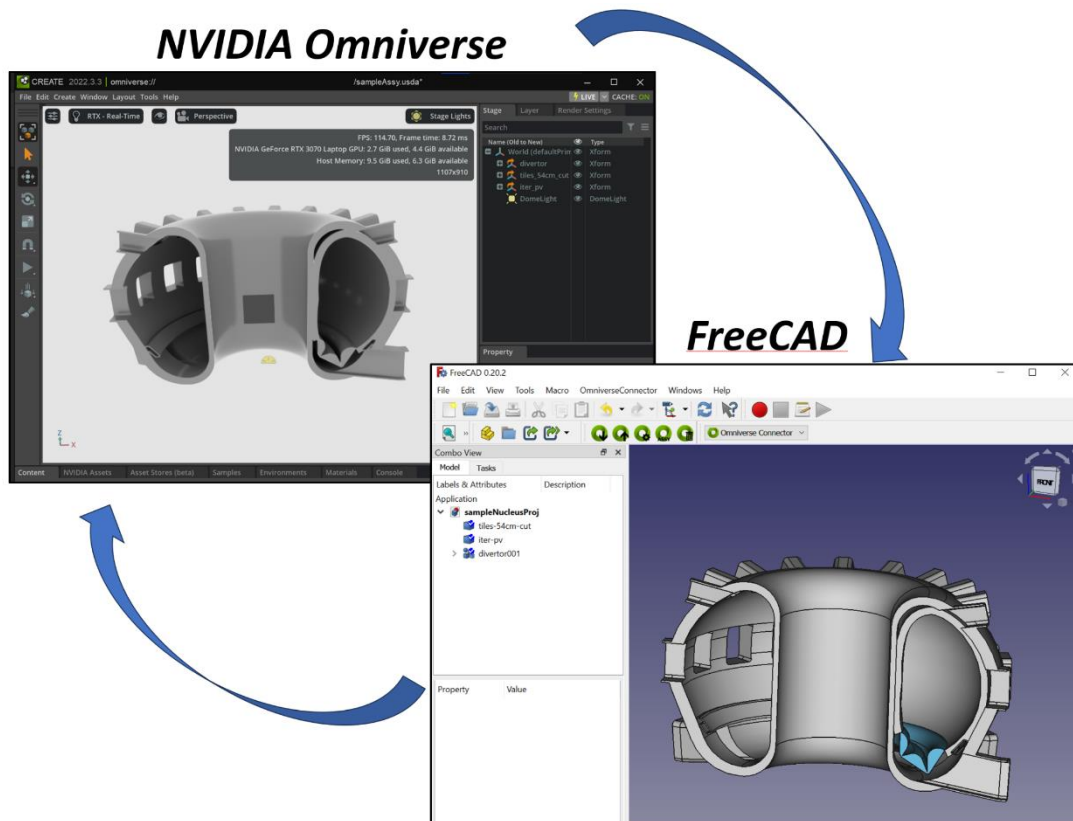# FreeCAD Connector for NVIDIA Omniverse

Documentation & Guide

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Contents

License

Introduction

For the field of computer-aided design (CAD), NVIDIA Omniverse presents an opportunity to improve on the workflows currently in place for both the initial design and continuous improvement of engineering components. Mainly, Omniverse serves as a shared 3D model exchange where contributors can create, view, and analyse the same model all while simultaneously conducting simulations in a true-to-life virtual environment.

The creation and analysis of engineering components in the context of Omniverse can be done using third-party connectors. Connectors offer real-time synchronisation between Omniverse and design and simulation tools currently in use. Due to Omniverse's open platform, several Omniverse connectors have been developed such as for Unreal Engine, ParaView, and Autodesk Maya, with the potential of developing further connectors through the Connect library.

FreeCAD is a general-purpose 3D computer-aided design tool. While not necessarily the main industry standard for CAD, its' open-source nature and modular architecture has allowed for introduction of numerous third-party 'workbench' tools expanding to a wider range of uses around engineering.

Currently, NVIDIA does not offer a connector between Omniverse and FreeCAD. Fortunately, the development of such a connector is made straightforward due to the availability of both open Omniverse Connect and FreeCAD Workbench platforms.

Installation

Installation of the Omniverse Launcher

The Omniverse Launcher is a piece of software that is required as a first step for setting up a local Omniverse Nucleus server. The provision of the software is free (at the time of writing of this document in May 2024) and allows access to NVIDIA's suite of Omniverse connected applications.

1. Navigate to the Omniverse main page at [nvidia.com/omniverse]. Under Software Development Kit (SDK), click Download now.
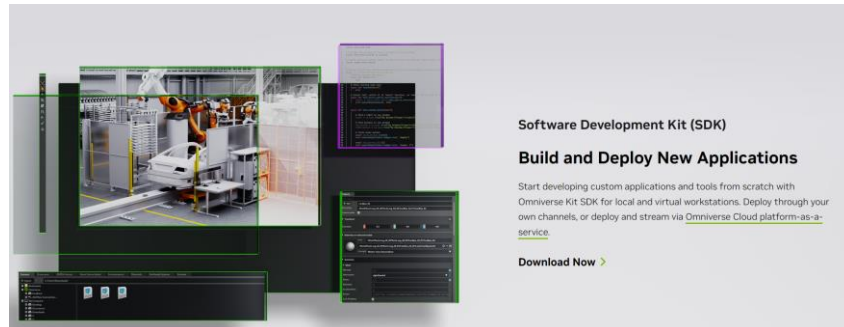
2. A prompt to register for the download will appear. Enter the user's details and select Submit to begin the download.

3. A file (omniverse-launcher-win.exe) will begin to download. Execute the file and complete all the necessary steps in the installer.
4. The launcher will display after the installation is done. The user may need to log in to the launcher – this is done through an NVIDIA account that the user has to setup.

Setting up a local Omniverse Nucleus server

The developed software relies on a connection with an Omniverse Nucleus server. Network clients requiring access to a given Nucleus server will require the server's IP address and hostname to be accessible to it. Using Nucleus behind a firewall and port forwarding network traffic inbound is not supported.

The FreeCAD connector can run on any Omniverse Nucleus setup. The most basic one can be downloaded using the Omniverse Individual license, which is free to use. The Omniverse Enterprise license requires a paid license subscription. There are some differences between Omniverse Individual and Omniverse Enterprise, however Omniverse Individual allows up to two users to work on the same project per entity.

Further information regarding the differences between Omniverse Individual and Enterprise is available here [https://docs.omniverse.nvidia.com/enterprise/latest/benefits.html].

Individual License
Setting up a local Nucleus service using the Omniverse Individual license can be done through the steps in the following link:
[https://docs.omniverse.nvidia.com/nucleus/latest/workstation/installation.html]
Once this is done, the user can access the Nucleus server using the newly created `omniverse://localhost` server.

Enterprise License
To set up an enterprise Omniverse Nucleus server, an extended user license is required, information regarding this and installation steps of the Omniverse IT-managed launcher can be found here [https://docs.omniverse.nvidia.com/launcher/latest/it-managed-launcher.html].

Basic installation (automated script)

The basic installation is the recommended method of installation and should work with most systems.

1. Git clone the FreeCAD Connector repository to your FreeCAD `\Mod` directory. Typically, this is `C:\Users\USER_NAME\AppData\Roaming\FreeCAD\Mod`.

   Command:
   ```
   git clone https://github.com/Metaverse-Colab-for-Fusion-
   Energy/FreeCAD-Omniverse.git
   ```

2. Navigate to the cloned repository's directory and launch the installation by running `install.bat`. This will fetch the dependencies required to run the software.

   Command:
   ```
   cd .\FreeCAD-Omniverse
   .\install.bat
   ```

3. The installation is complete and the FreeCAD connector for Omniverse is ready for use.

Note: if the `AppData\Roaming\FreeCAD\Mod` file directory does not exist, you must first initialise this folder. This happens if no FreeCAD addons have been previously installed. To do this, launch FreeCAD, and on the toolbar click `Tools` > `Addon Manager`. If you are using the Addon Manager for the first time, a dialog box will open, warning you that the addons in the Addon manager are not officially part of FreeCAD. It also presents several options related to the Addon Manager's data usage. Adjust those options to your liking and press the `OK` button to continue. The `\Mod` directory should now exist.

Manual installation

This subsection outlines the steps required to install the software manually, without using the automated script. The user will have to have Omniverse Launcher installed prior to carrying out this installation process.

1. Git clone the FreeCAD Connector repository to your FreeCAD `\Mod` directory. Typically, this is `C:\Users\USER_NAME\AppData\Roaming\FreeCAD\Mod`.

   Command:
   ```
   git clone https://github.com/Metaverse-Colab-for-Fusion-
   Energy/FreeCAD-Omniverse.git
   ```

2. Open Omniverse Launcher. Under the Exchange tab, navigate to the Connect Sample page. This can be done using the search bar or under the Connectors tab on the left-hand side of the window.
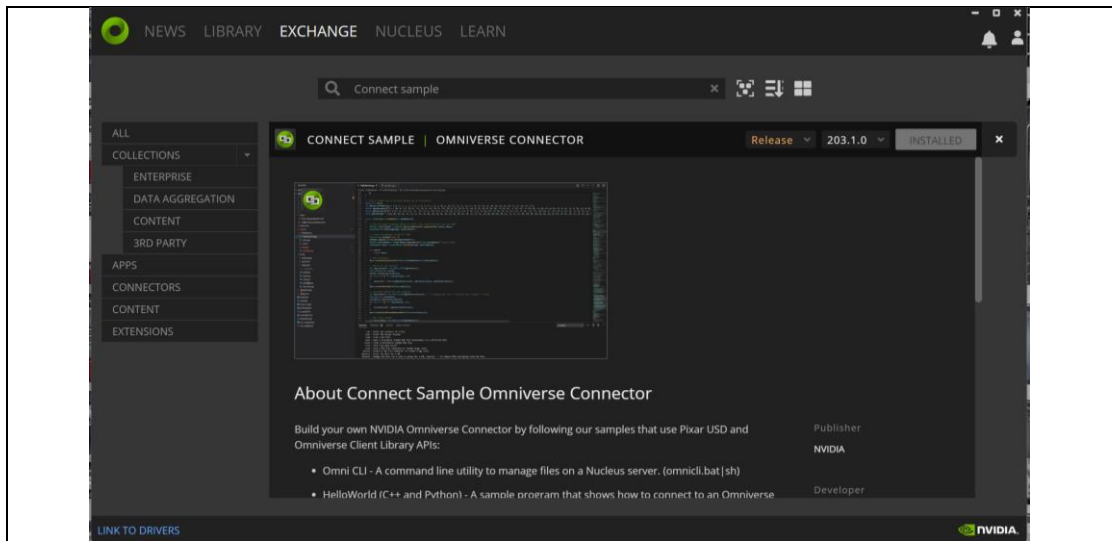
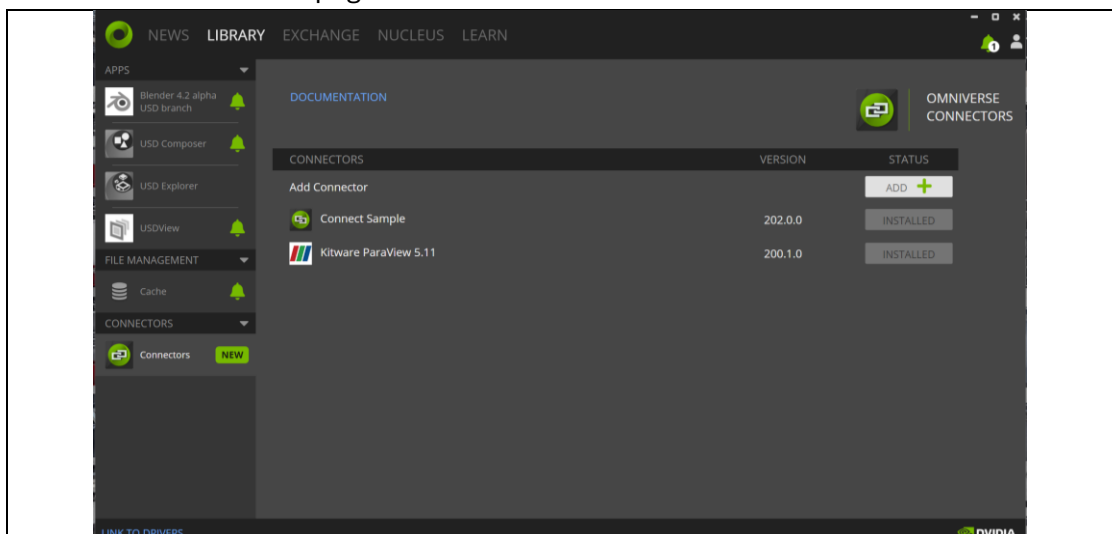3. Download Connect Sample version 202.0.0 using the Omniverse Launcher. The estimated file size is around 200MB.

4. Once downloaded, navigate to the Library tab. On the left-hand side of the page, select Connectors. The user can expect to find the newly downloaded Connect Sample connector visible on the page.

5. Click the three horizontal bars to the right of the Connect Sample listing. Click Settings.
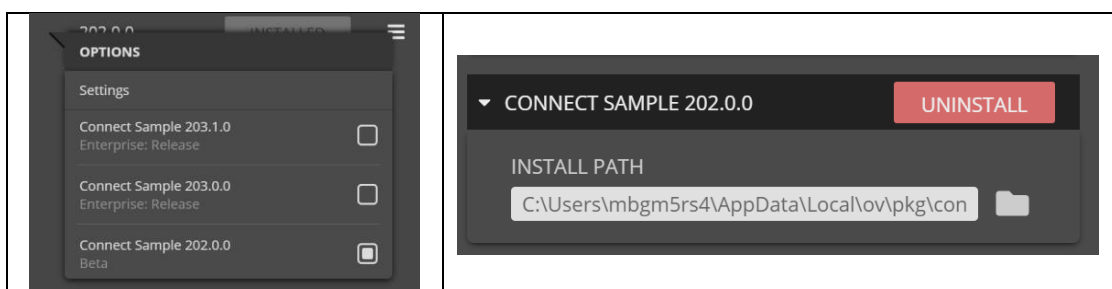
6. Clicking the folder icon to the right of the install path will direct the user to the directory in which the Connect Sample is stored. Alternatively, this is typically stored in `C:/Users/USERNAME/AppData/Local/ov/pkg/connectsample-202.0.0`
7. Copy the contents of the directory to the `/OmniConnect` folder of the FreeCAD-Omniverse repository directory, which was previously downloaded in step 1.
8. Navigate to the `/OmniConnect` directory in the FreeCAD-Omniverse repository directory. Under `/omniConnect/source/PyHelloWorld`, copy the entire \omni directory to `/omniConnect/source/pyOmniFreeCAD.` The pyOmniFreeCAD folder should now contain all these files:
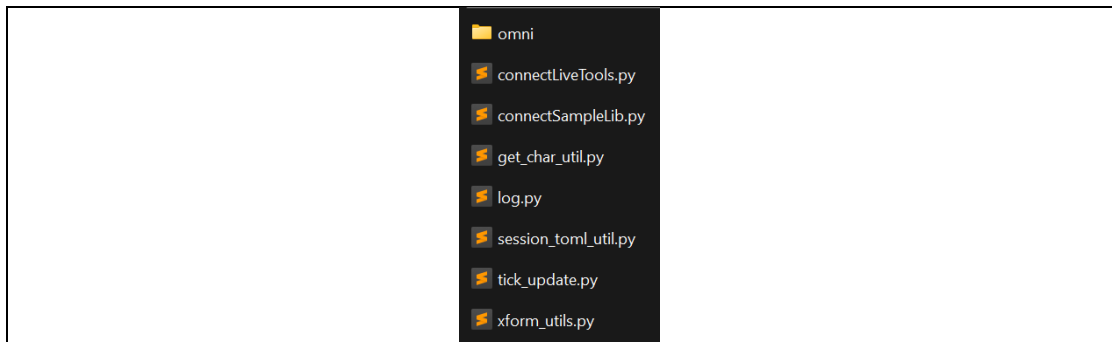
9. Navigate to the `/OmniConnect` directory, and using a Powershell terminal run the command below to fetch the required NVIDIA dependencies:

Command:
```
./repo.bat build --fetch-only
```

10. Still in the /OmniConnect directory, run the following command to fetch the remaining Python dependencies:

Command:
```
./_build/target-deps/python/python.exe -m pip install open3d
aioconsole
```

11. The installation is complete and the FreeCAD connector for Omniverse is ready for use.

System

In this software, geometry is pushed to the Nucleus in a neutral .STP format, which preserves the information initially attached by FreeCAD and does not require importing of tessellated geometry into the FreeCAD workspace. Along with the STP file, the connector uploads a USD file, which is updated whenever a new version of its corresponding STP file is made. However, the connector imports only the stored STP file when pulling from Nucleus. The tessellation process is done only once for each version of the geometry: during the upload process of a STP file.
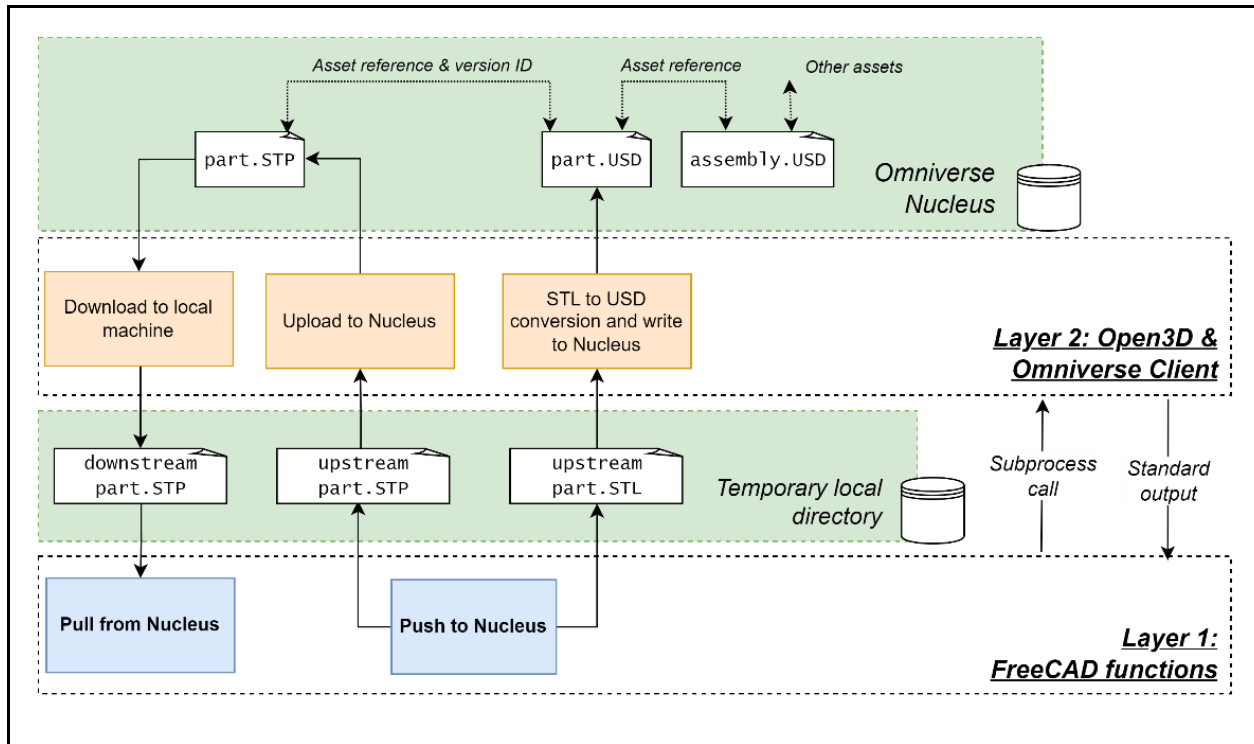
USD and STP files are stored in a project folder, which contains single-component assets and assemblies. By default, projects are stored in:

`omniverse://HOST_NAME/Projects/FreeCAD/$PROJECT_NAME` (public folder)

or if they are set as private projects:

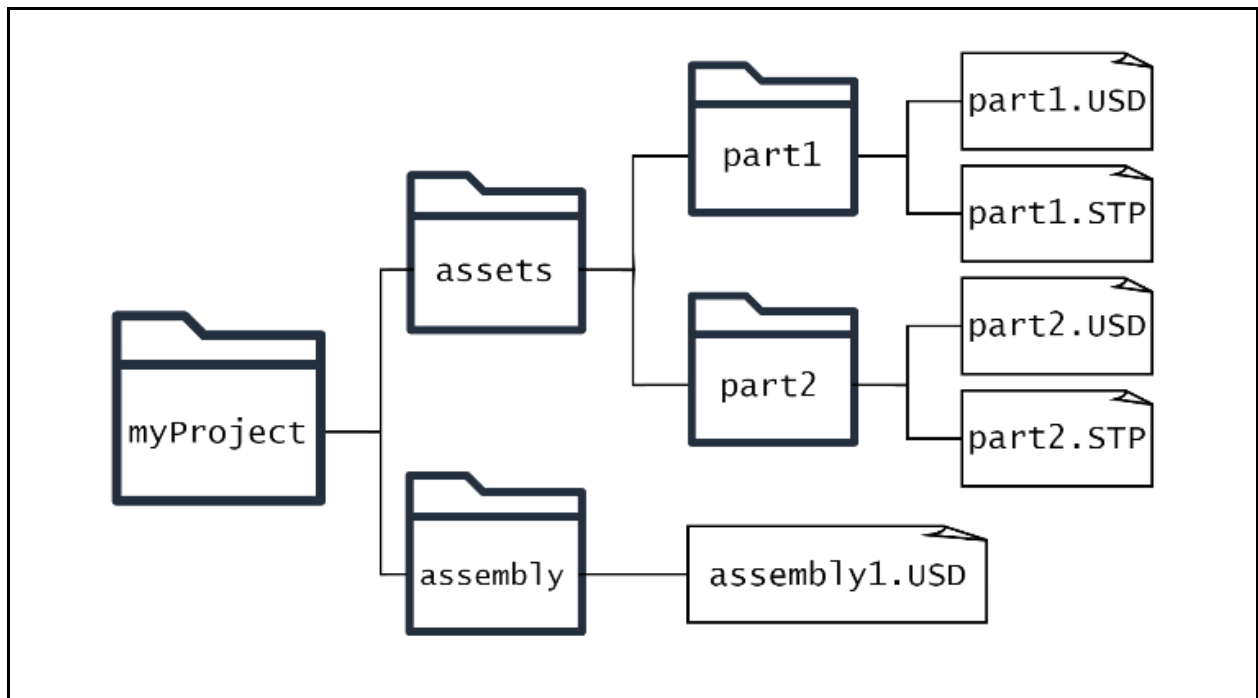`omniverse://HOST_NAME/Users/$USERNAME/FreeCAD/$PROJECT_NAME` (private folder)

STP and USD assets are stored in:

`$PROJECT_FOLDER/assets/$ASSET_NAME/`

and assemblies stored as:

`$PROJECT_FOLDER/assembly/$ASSEMBLY_NAME.usda`

This is shown in the image below.

Each asset's USD and STP files are attached to a checkpoint message which can be viewed on any Omniverse application. After every upload, download, or assembly task triggered by the FreeCAD connector, a unique token is attached to the checkpoint message of the file. STP and USD files which are associated with the same task are identical and as such can be used as a way to track different versions of the CAD geometry.

User interface

The user can launch tasks using the ribbon menu, the settings panel, or the assembly panel. For reference, these user interface buttons are shown below.
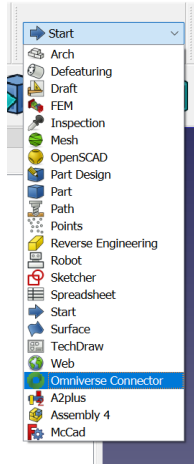
Ribbon menu buttons
①　　　　　②　　　　　③　　　　　④
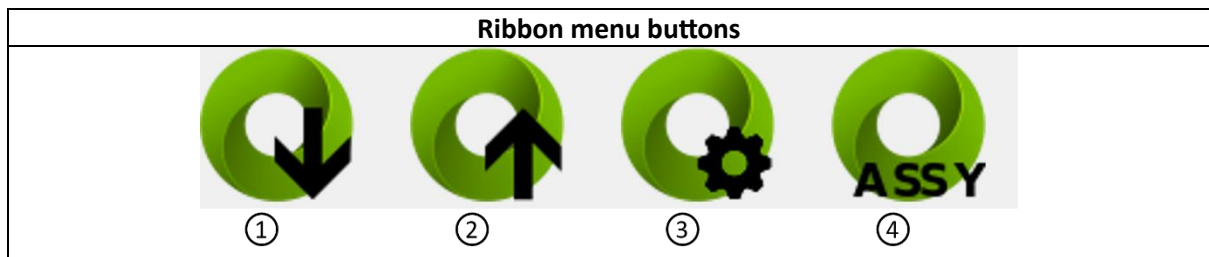
No	Button name	Description	Mode of activation
1	Pull from Nucleus	Pulls the specified asset from Nucleus into the FreeCAD workspace.	Active if a project link and asset has been specified
2	Push to Nucleus	Pushes geometry in the FreeCAD workspace onto Nucleus using the specified project link and asset.	Active if a project link and asset has been specified
3	Settings Panel	Button to open the Settings Panel.	Always active
4	Assembly Panel	Button to open the Assembly Panel.	Active if a project link has been specified

Settings Panel	Assembly Panel
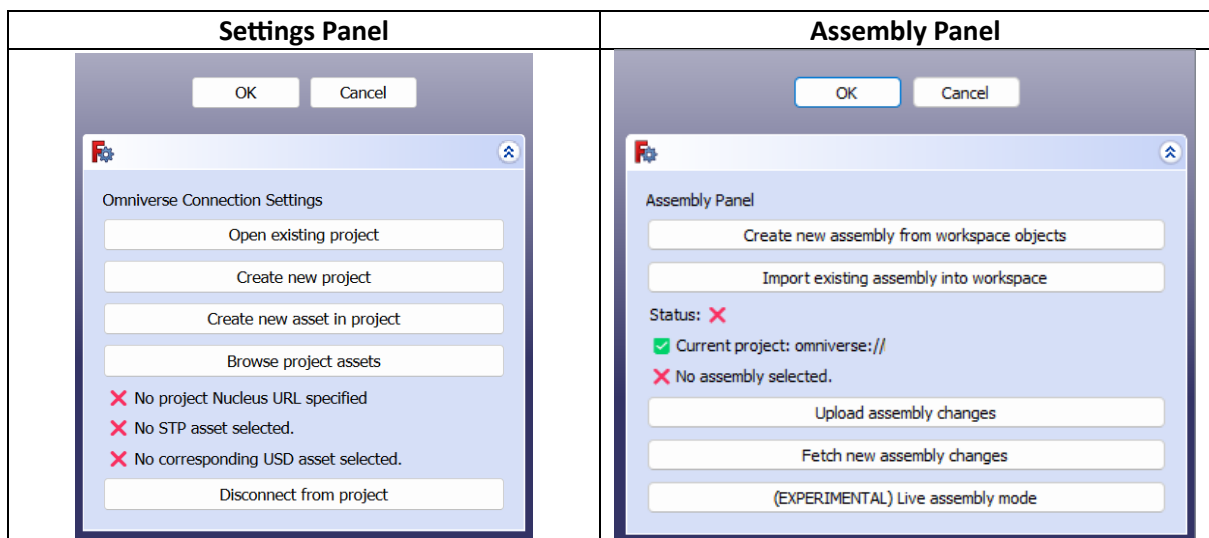
How-to guide

Activating the FreeCAD-Omniverse Connector

1. Create or open a new document on FreeCAD.
2. Using the Workbench selector, select the Omniverse Connector Workbench.

3. The Omniverse Connector is now active. The ribbon menu should show the Settings Panel and Clear Session buttons active with others greyed out.
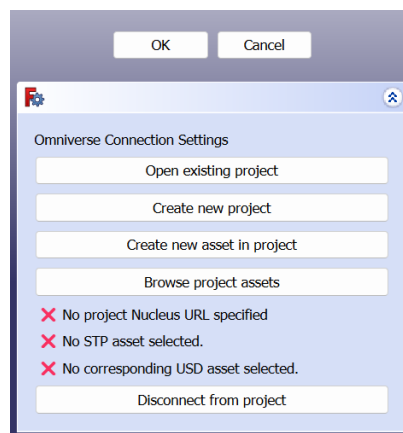

Establishing a connection with Nucleus

Establishing a connection with a component stored on the Nucleus is done through a project-based process. Users can create a new project or connect with an existing one.

Creating a new project

1. Select the Settings Panel on the ribbon menu and click 'Create New Project'.
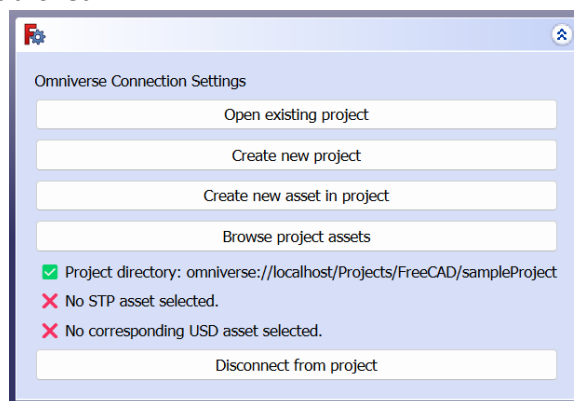

2. This will prompt the user to input the Nucleus hostname and the new project name. An option to make the project private will appear in this prompt. If this is checked, the project will be saved in the Nucleus's `/Users/USERNAME/FreeCAD directory`. If it is left unchecked (as the default option), the project will be saved in the Nucleus's `/Projects/FreeCAD` directory.
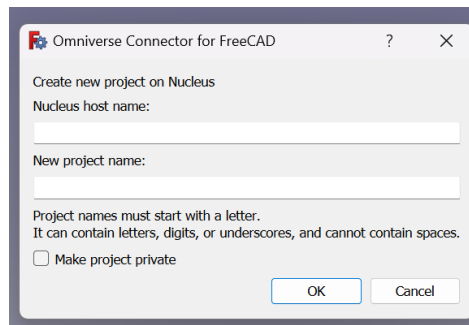
3. Click OK in the pop-up prompt. If the user has not logged in to the Nucleus server previously, a prompt to log in using the user's credentials will appear on the user's default web browser.
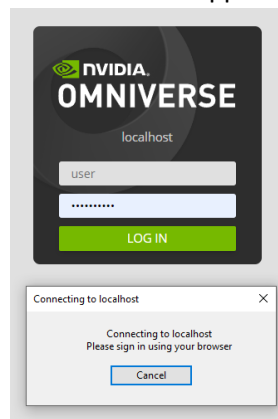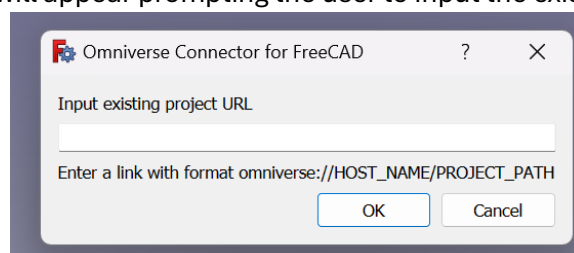

4. If the connection is successful and the project has been successfully created, the Project Directory indicator on the Settings Panel will change into a green tick box. The connection with Nucleus has been established.

Connecting to an existing project

1. Select the Settings Panel on the ribbon menu and click 'Open existing project'.
2. A pop-up window will appear prompting the user to input the existing project path.

3. If the user has not logged in to the Nucleus server previously, a prompt to log in using the user's credentials will appear on the user's default web browser.

4. If the connection is successful, the Project Directory indicator on the Settings Panel will change into a green tick box. The connection with Nucleus has been established.

Disconnecting from an existing project

1. Select the Settings Panel on the ribbon menu and click 'Disconnect from project'.
2. The connection with the Nucleus server is now terminated. This will reflect in the Settings Panel.
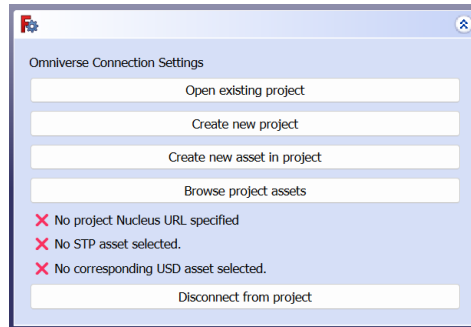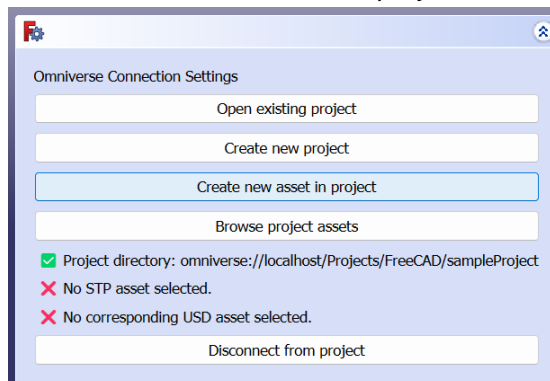

# Interacting with Nucleus assets

Nucleus assets are geometry files that can be imported into FreeCAD for editing and sent back to Nucleus for storage. A user needs to have connected to a project first before interacting with its assets.

Creating an asset

1. Using the Settings Panel, click 'Create new asset in project'.

2. A pop-up window will appear prompting the user to input a new name for the asset.
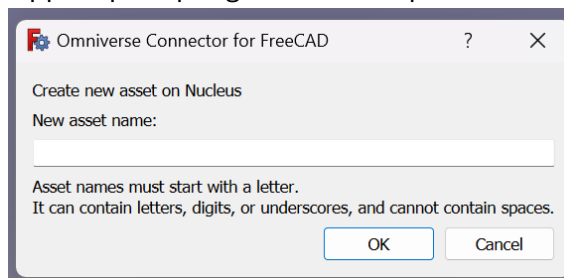

3. Clicking OK will show the Settings Panel with three green tick boxes. It will also indicate the name of the newly created asset. The user is now connected to the new asset.

Uploading geometry to an asset

1. The newly created asset is empty, and as such the user needs to upload new geometry to it. To do this, the user needs to create or import new geometry in FreeCAD.

2. Switch back to the Omniverse Connector Workbench and click the object to be uploaded in the FreeCAD Model view or the workspace. The object should be highlighted green.
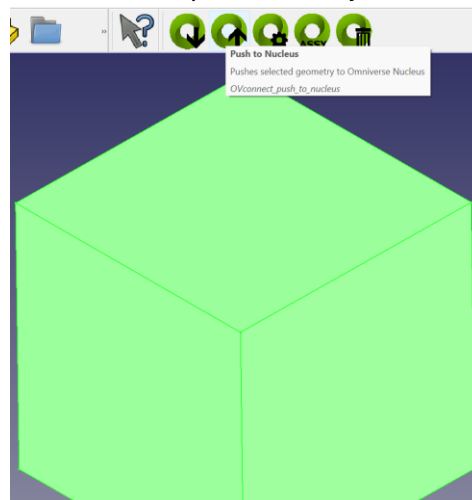

3. Click the 'Push to Nucleus' button on the ribbon menu to upload the geometry.
4. The geometry is now uploaded to the specified asset. The user can alsocheck for this information in the FreeCAD object's property tab.

Connecting to an existing asset

1. Using the Settings Panel, click 'Browse project assets'.
2. A pop-up window will appear prompting the user to select an asset. Select the desired asset and click OK.
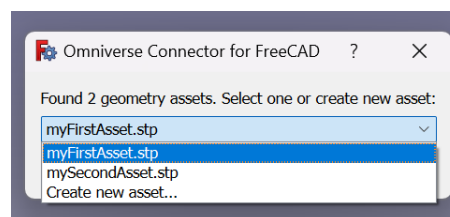
3. Clicking OK will show three green tick boxes in the Settings Panel along with the selected asset's name.
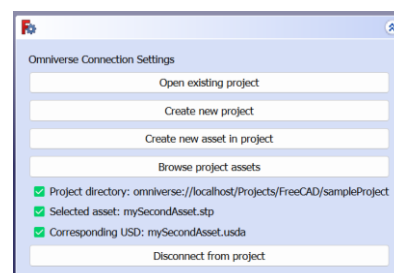
4. The user is now connected to the existing asset.

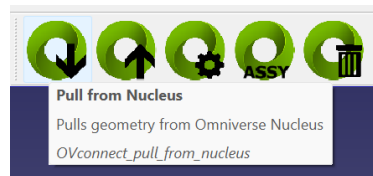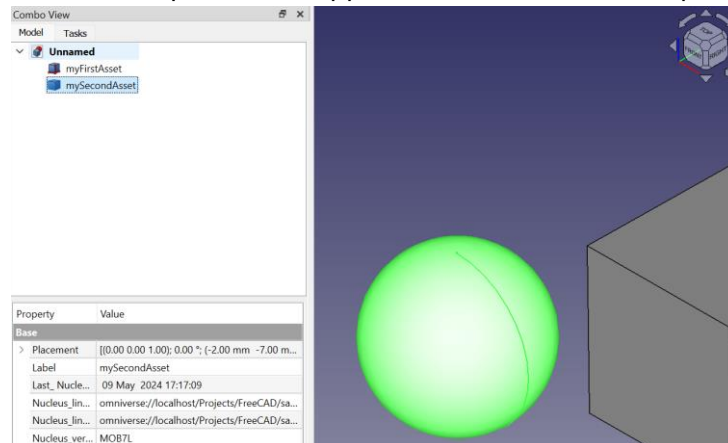1. Once an asset is connected, the associated asset geometry can be imported into the FreeCAD workspace if it is not an empty asset. Importing the asset is done using the 'Pull from Nucleus' button on the ribbon Menu.

2. The asset should now be imported and appear in the FreeCAD workspace.

Assembly tools

The push-pull assembly workflow provides a way for the FreeCAD user to use the various assembly functionalities of FreeCAD such as that found on the standard Part workbench, A2plus, Assembly3, or Assembly4, and propagate the component placement to a USD file on the Omniverse Nucleus.

The main user interface for the assembly feature in the FreeCAD connector is the Assembly Tools panel.
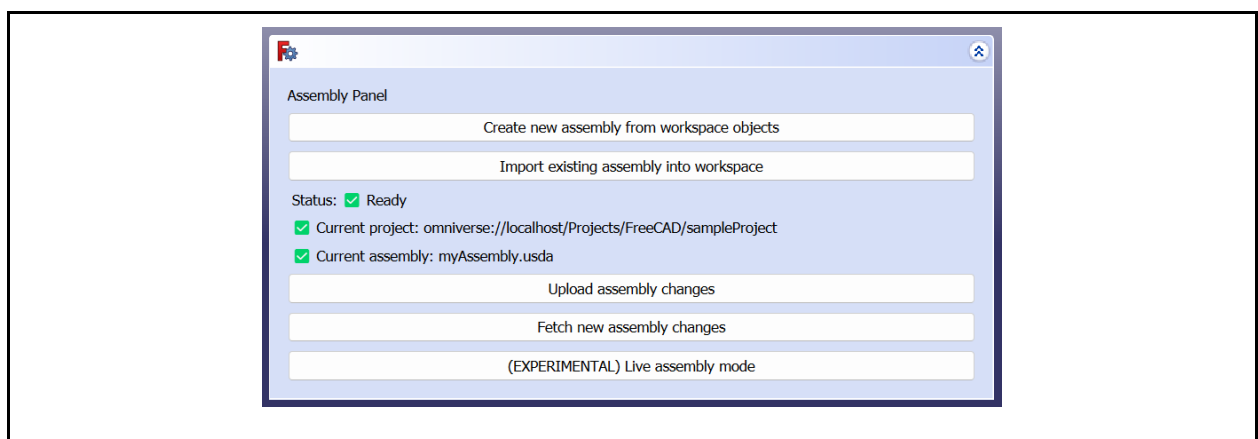
The panel contains 5 different buttons. The 'Create new assembly' button allows the user to create a USDA file on the Nucleus server which references the USD objects in the current FreeCAD workspace. Clicking this button opens a pop-up menu that prompts the user to input an assembly name and to select items in the workspace to include in the assembly. A new USDA

file will be made in `$PROJECT_FOLDER/assembly/`, containing only references to the USD component, that can be visualised on Omniverse in the same placement as that on FreeCAD. The 'Import existing assembly' button will open a pop-up menu that prompts the user to select an existing assembly from the current project folder. Upon selection, the entire assembly and its components will be imported into the FreeCAD workspace.

Under these two buttons, status indicators are given, detailing the current project and assembly in use in the given session. If both current project and assembly elements are valid, the status will show the 'Ready' indicator, which allows users to access the 'Upload assembly changes', 'Fetch assembly changes', and 'Live assembly mode features' buttons.

The remaining buttons allow the user to transfer positional information (translation and rotation) to and from the Nucleus server. The 'Upload assembly changes' button sends the cartesian coordinates and rotation of each component in the current FreeCAD assembly to the assembly USDA file stored on the Nucleus and alters the position of each referenced single component within the assembly USDA file. Meanwhile, the 'Fetch new assembly changes' button requests the coordinates and rotation of each element in the assembly USDA file stored in the Nucleus server and adjusts each component's rotation and translation in the FreeCAD workspace. These two buttons allow for simple manipulation of position and angle of the components, integrated with the Omniverse environment.
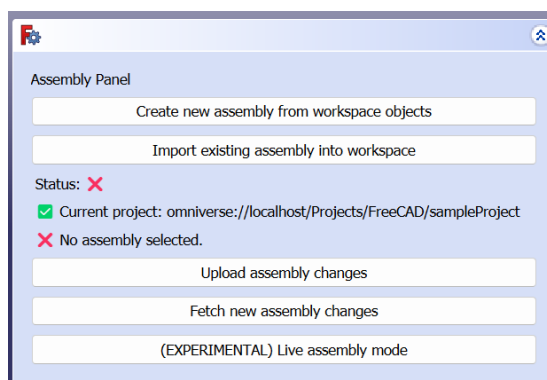
Creating a new assembly

Prerequisites:

- The user must be connected to an existing Nucleus project.
- All components intended to be included in the assembly must have already been uploaded to the Nucleus project.
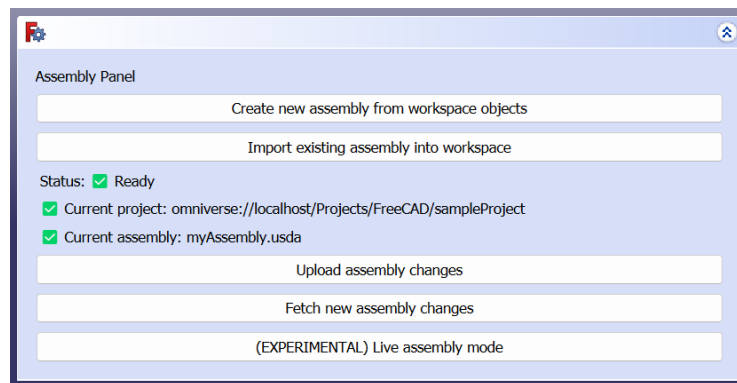
Steps:

1. Using the Assembly Tools button in the ribbon menu, click 'Create new assembly from workspace objects'

2. A pop-up window will appear prompting the user to input a new name for the assembly and select geometry in the workspace to include in the new assembly. Note: only geometry that has been pushed to the Nucleus project will appear.
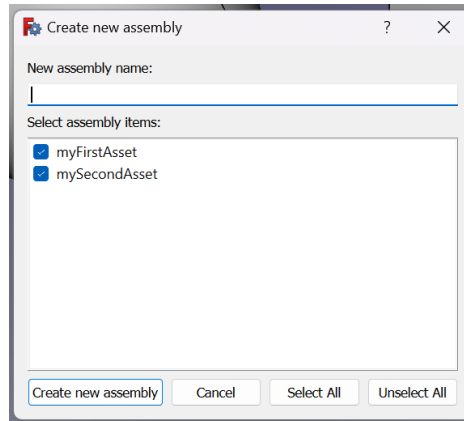
3. The assembly panel will show three tickboxes and the status text will show 'Ready'. This indicates positional and rotational changes in the geometry can be synced from FreeCAD and Omniverse.

Importing an existing assembly

Prerequisites:

- The user must be connected to an existing Nucleus project.
- The Nucleus project must contain an existing assembly.

Steps:

1. Select 'Import existing assembly into workspace' on the Assembly Panel.
2. A pop-up window will appear prompting the user to select an existing assembly from a list. Only assemblies associated with the user's project will appear from the list. Select an assembly file and click OK to confirm.

3. The assembly file will be imported into FreeCAD and will appear on the FreeCAD workspace. The assembly panel will show three tickboxes and the status text will show 'Ready'. This indicates positional and rotational changes in the geometry can be synced from FreeCAD to Omniverse.
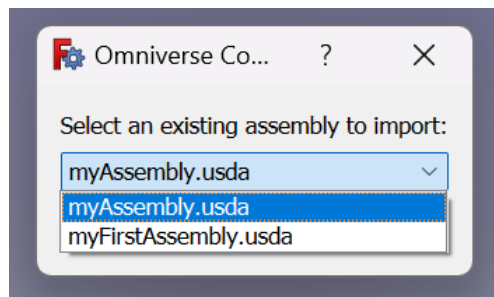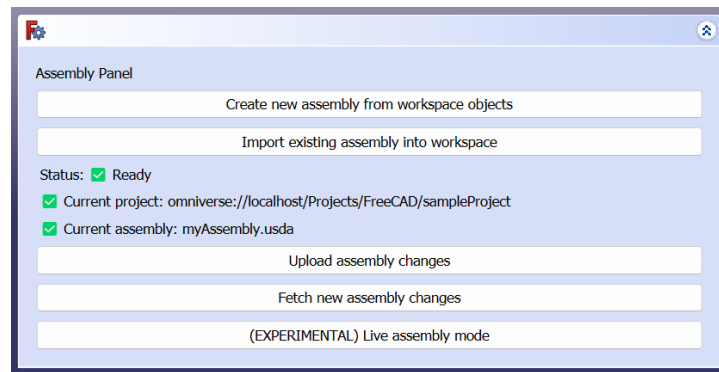
Synchronising assembly changes

An assembly file created or imported using the FreeCAD connector can by synchronised with its counterpart hosted on a Nucleus server. The user has to ensure that the 'Ready' status indicator is shown in the Assembly Panel for this to be possible.

To obtain updates in positional and rotational information of the components within the geometry, the user can use the Assembly Panel's 'Fetch New Assembly Changes' button. Doing so will move the objects in the FreeCAD workspace to match that found in its Nucleus counterpart.

To update the positional and rotational information stored on Nucleus, the user can click the 'Upload Assembly Changes' button on the Assembly Panel. This button changes the position and rotation of the geometry stored in the selected assembly file stored on Nucleus to match that in the FreeCAD workspace.

Connecting with a live session

The 'Live assembly mode' button allows for live real-time communication between the FreeCAD workspace and Omniverse environment.

Prerequisites:

1. The user must be connected to an existing Nucleus project.
2. The user must have an existing Nucleus assembly imported into the FreeCAD workspace.
3. The Nucleus assembly has to have an existing live session. Creation of a new live session can be done using any Omniverse application. Steps to create an Omniverse live session can be found in the following [link](#):

    [https://docs.omniverse.nvidia.com/extensions/latest/ext_core/ext_live/sessions.html]

Steps:

1. Using the Assembly Panel, click on the 'Live assembly mode' button. This will open a pop-up window prompting the user to select an existing live session.
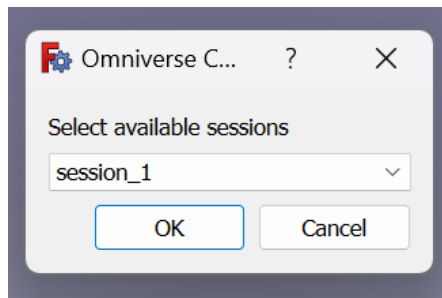
2. On FreeCAD, the Live Assembly Mode button will show that it is active and toggled in blue. Movement of components in the live session on Omniverse will be streamed to the FreeCAD workspace in real-time.

3. If the assembly USDA file is opened on Omniverse USD Composer and a user is logged into the same Live Session as the FreeCAD user, a small user icon will appear near the Live button of the USD Composer app. Also, a message will appear on the USD Composer notifying the user that another user has joined the session.
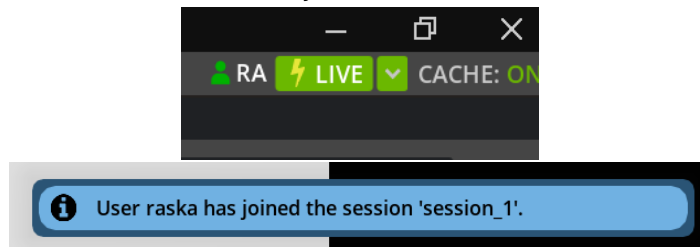
4. Clicking the 'Live assembly mode' button again on FreeCAD deactivates Live mode, triggering the Omniverse Client to quit the Live Session and thus turning the button white in the process.