

# Solve Clashes Automatically with Forge, BIM 360 & Revit Design Automation

**Xiaodong Liang**

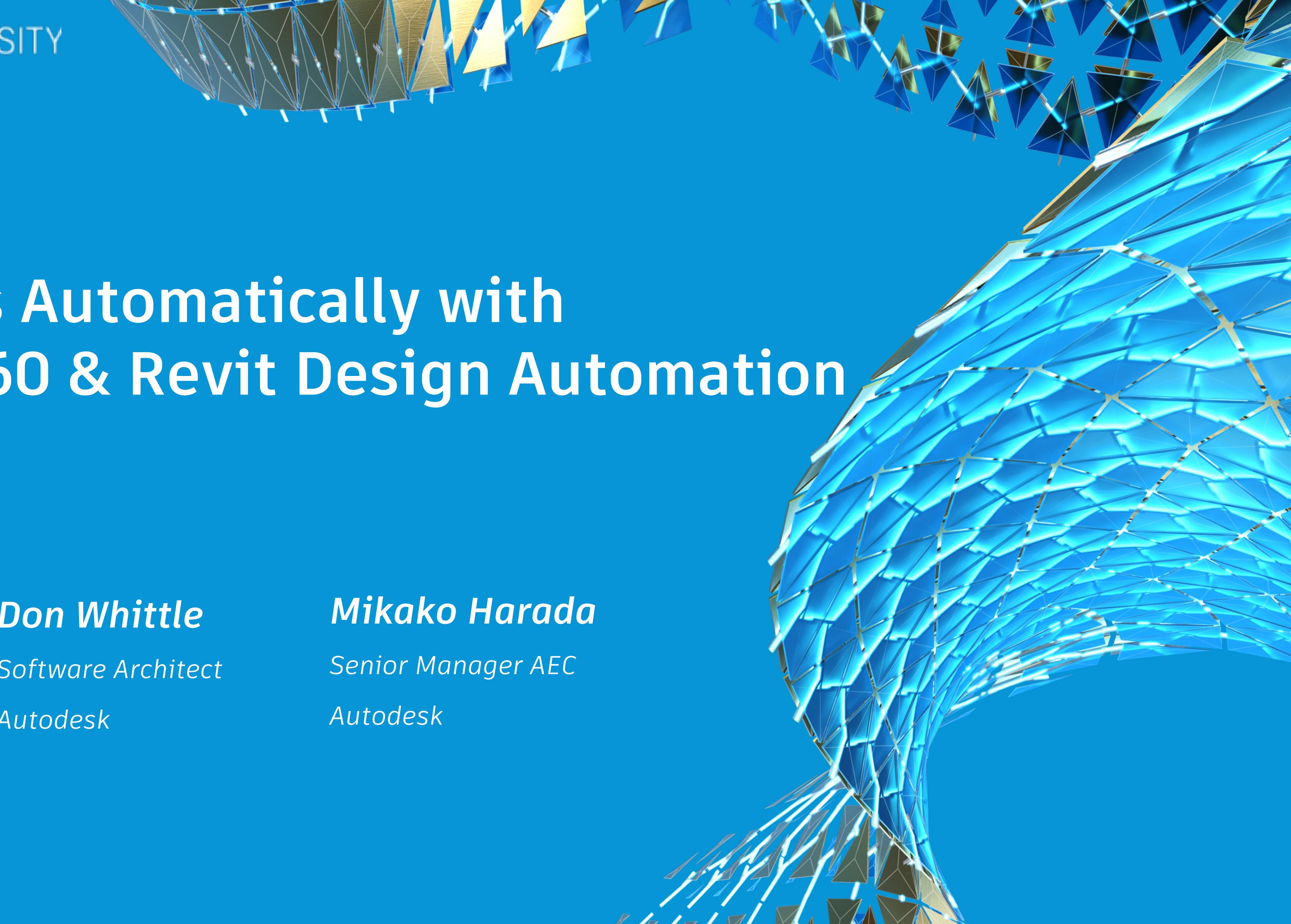
Principal Consultant  
Autodesk

**Don Whittle**

Software Architect  
Autodesk

**Mikako Harada**

Senior Manager AEC  
Autodesk





Xiaodong Liang  
Principal Advocate

Joined Autodesk in 2007 as a developer advocate. Starting with desktop products' APIs, he is now engaging in Autodesk Forge and AEC solutions. He is one of the contributors of ADN DevBlog and Forge blog. He is based in China, yet mingling with the global community of Autodesk and programming.



Don Whittle  
Software Architect

Joined Autodesk in Feb 2017 as the Software Architect for BIM 360 Model Coordination, based in Sheffield, UK and working with teams across BIM 360. Have over 20 years experience of building distributed client server applications in hosted environments and have worked on applications and services in many different verticals for both large enterprises and small start-ups. Since 2011 I have been exclusively working with teams developing native cross-platform mobile and browser-based web applications running in the cloud on Azure and AWS.



Mikako Harada  
Senior Manager AEC

Senior manager for Forge/Developer Technical Services team at Autodesk. She provides API technical support for AEC products, such as Revit and BIM 360. Her interest is in the areas of interactive techniques, optimization and layout synthesis. More at her blog:

<https://fieldofviewblog.wordpress.com/>

# Disclaimer

This presentation includes the demonstration of sample application and discusses about the potential use case for future. **They are experimental, using public APIs available today.** They are not meant to represent the product roadmap. Rather, they are meant to help us imagine what is possible and learn what's needed to work toward our goal.

# Agenda

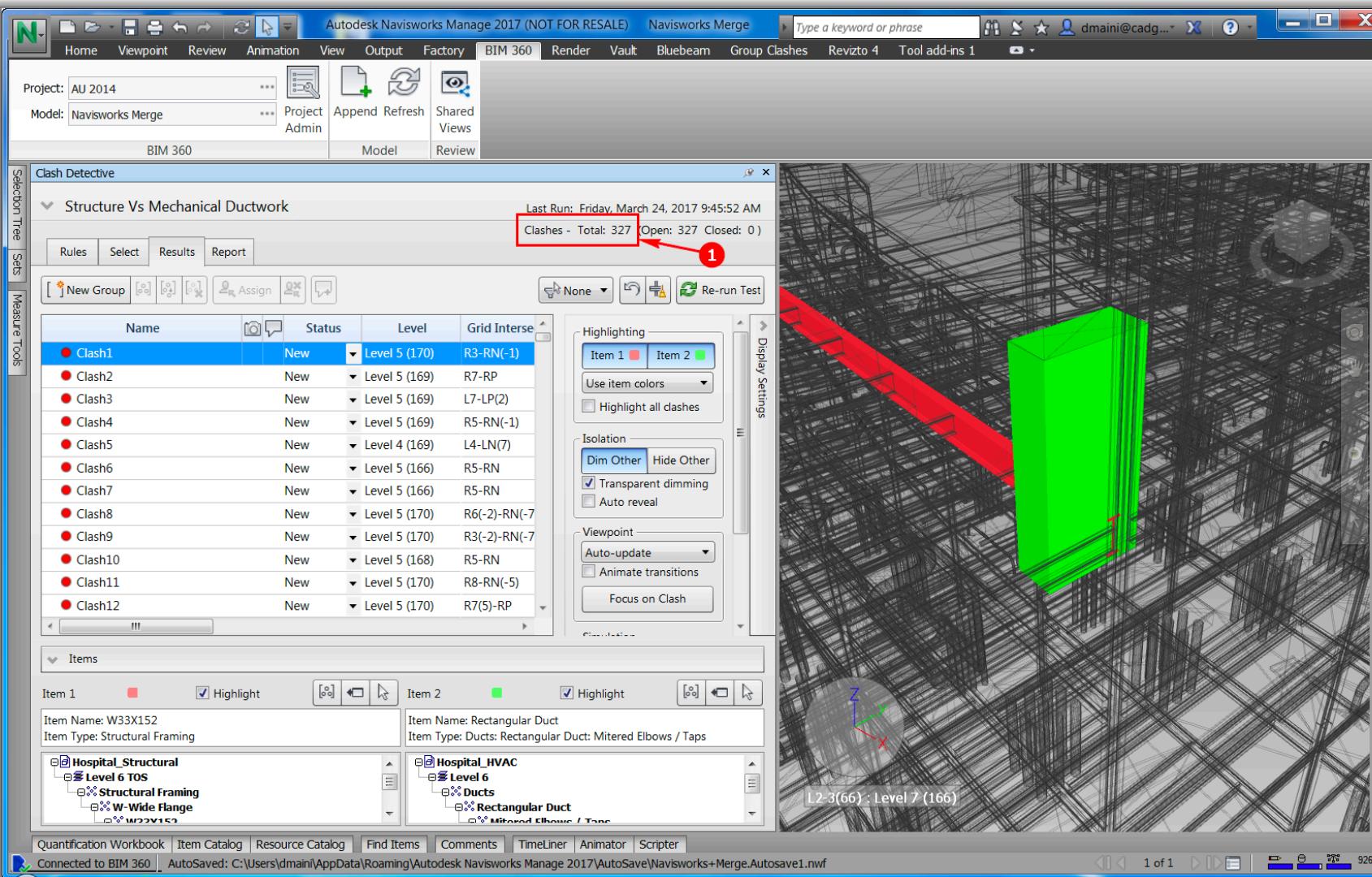
- Background and Motivation
- Analyzing Clashes
- Solving Clashes
- Developer Tools Behind
  - Model Coordination API
  - Design Automation API
- Lessons Learned and Future Work

# Background and Motivation

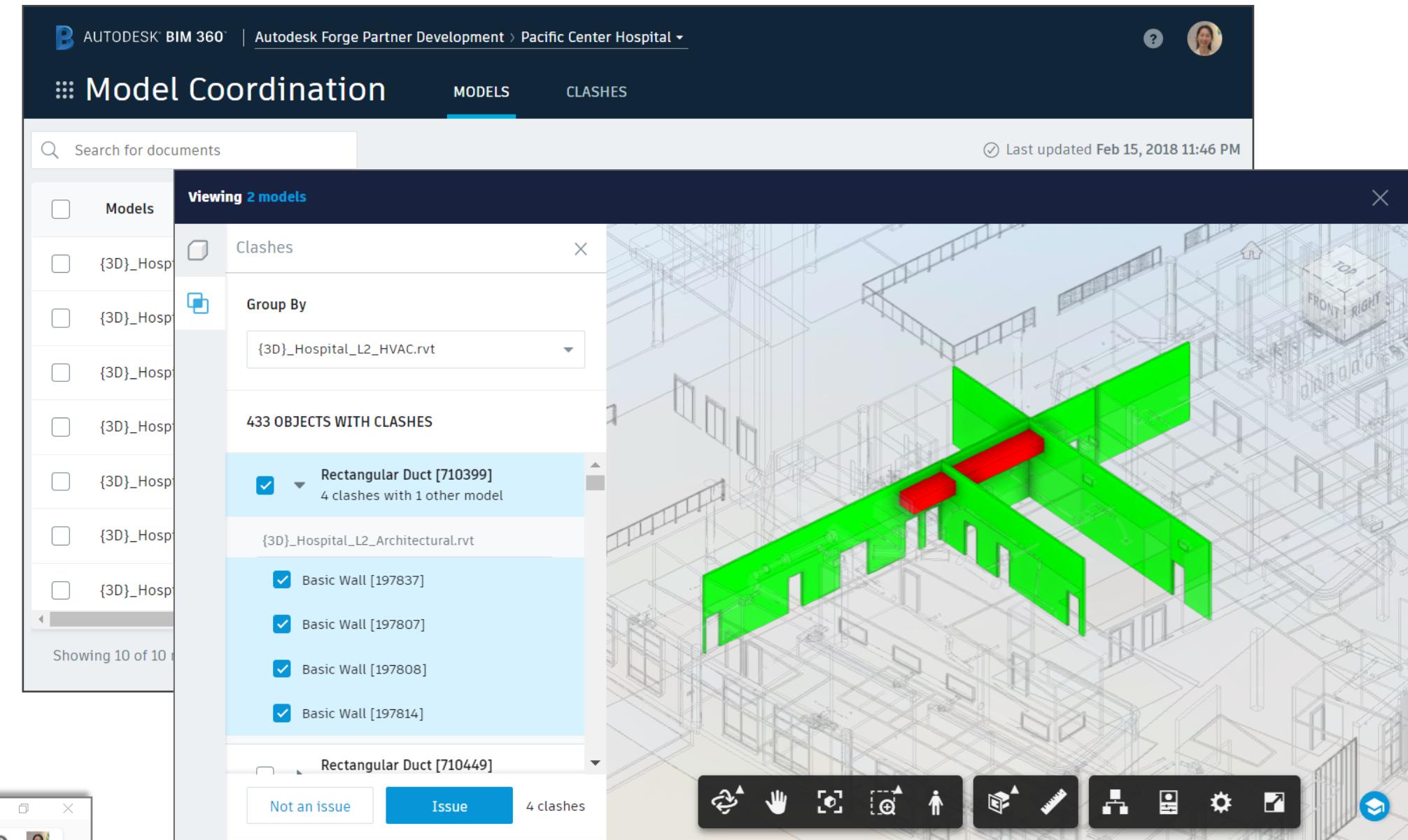


# Coordination Tools

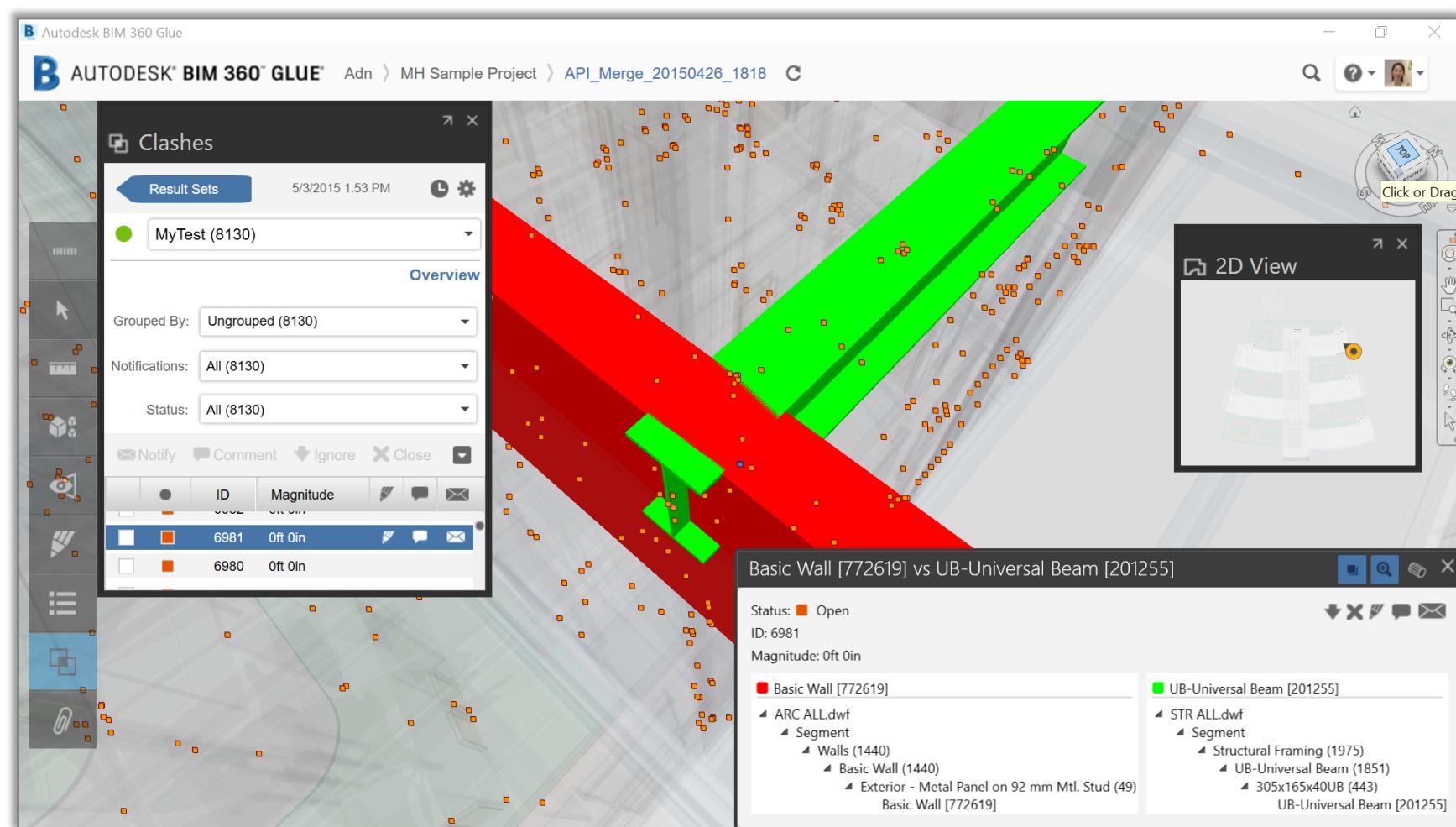
## Navisworks



## BIM 360 Model Coordination



## BIM 360 Glue



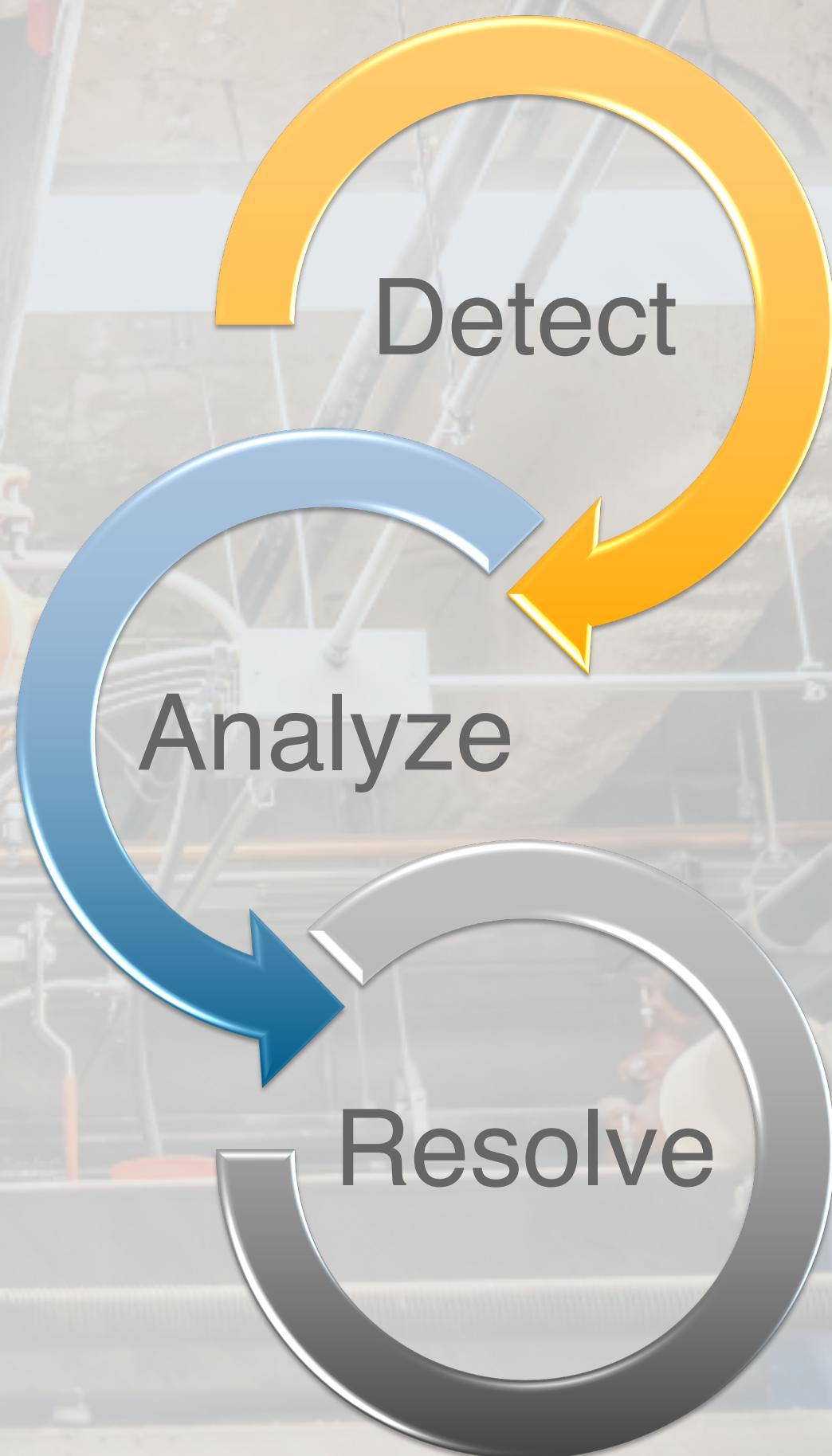
# Coordination Tools

Detect clashes automatically

Present with thousands of clashes

What's next?

Go beyond clash detection



# Technologies

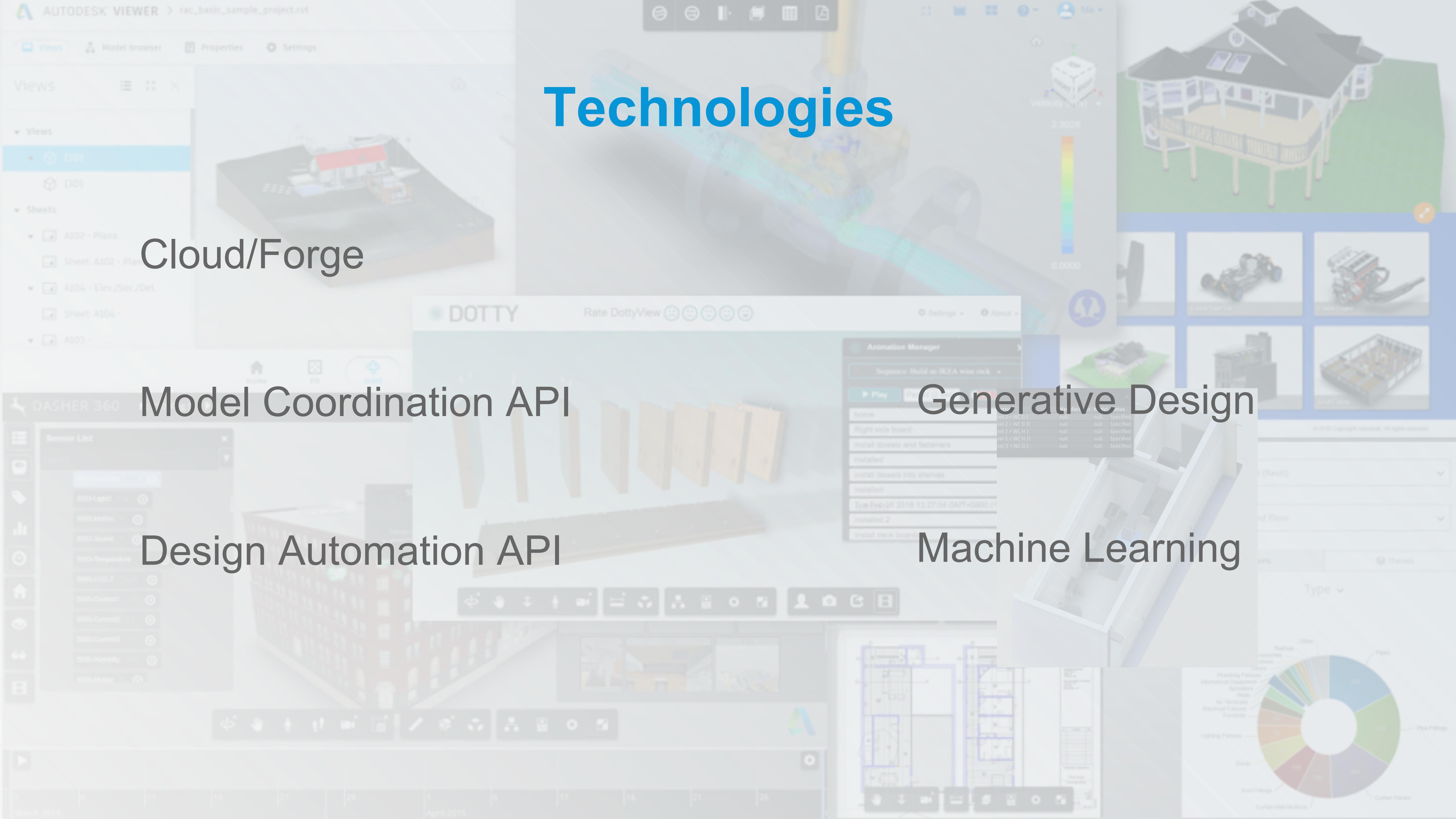
Cloud/Forge

Model Coordination API

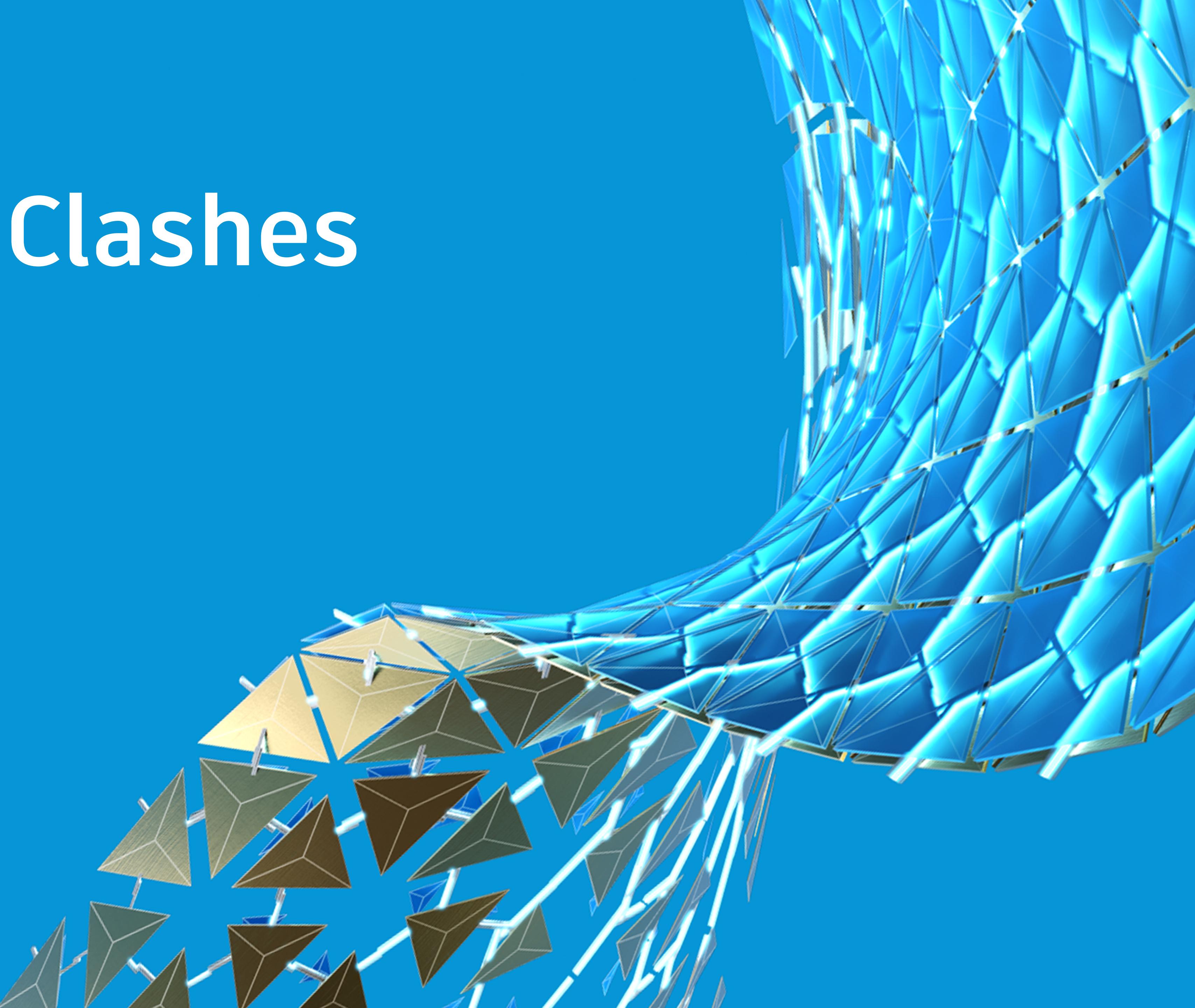
Design Automation API

Generative Design

Machine Learning



# Analyzing Clashes



# Analyzing Clashes

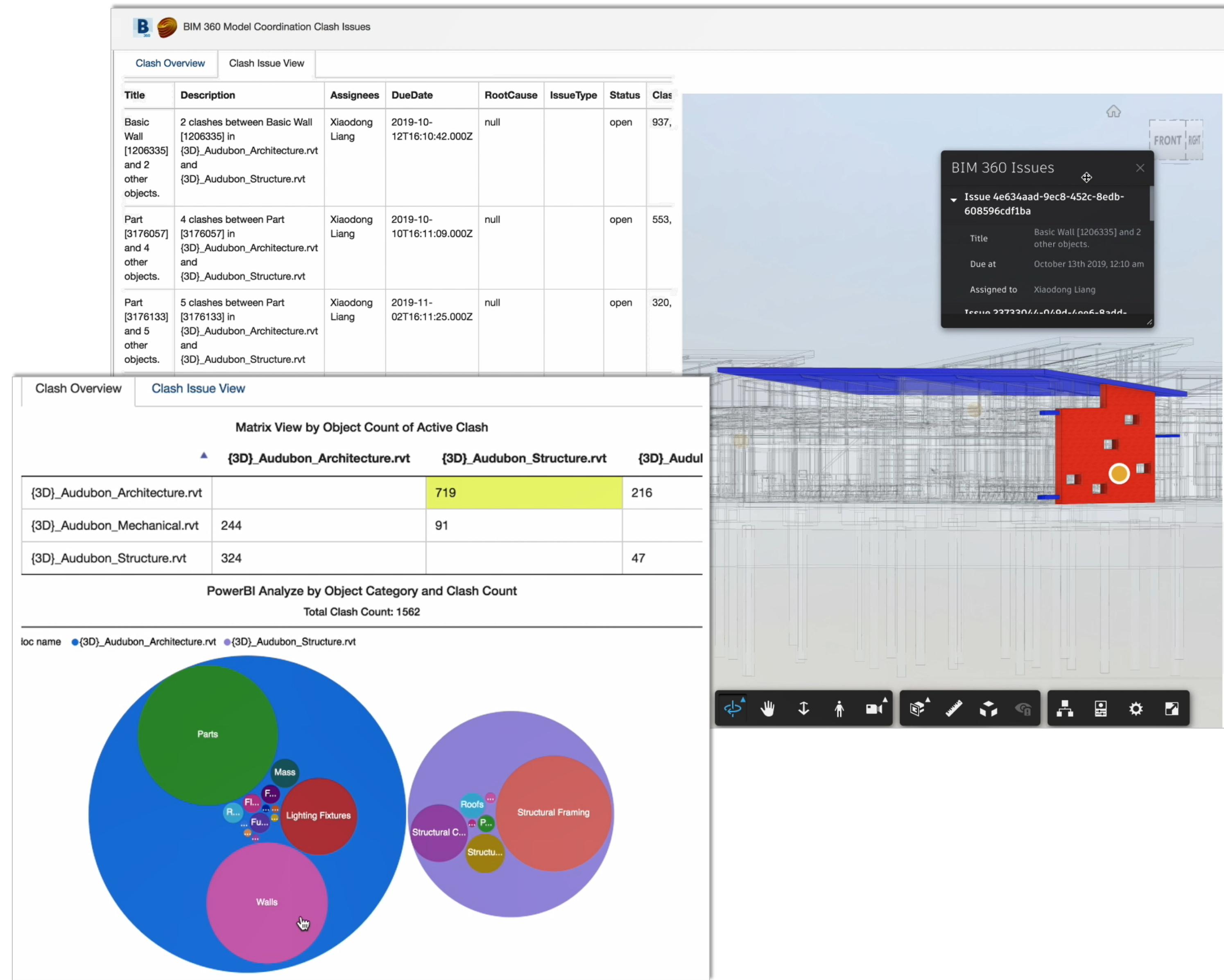
- Visualization of clash data
  - Integrating with analytics software. e.g., Power BI
    - Bubble diagram, tree maps, matrix table
  - Integrating with the model viewer
    - By level, by room
- Analyzing by functional sets of elements
  - e.g., MEP systems
  - May requires Design Automation

# Bubble Diagram, Issues

What it does: clash counts in a bubble diagram (PowerBI). Issues w/ clash information.

Code: [GitHub Sample](#)

Author: Xiaodong Liang, Autodesk





## BIM 360 Projects List

- [Daimler POC Project](#)
- [Accelerator Sydney sample by Zhong](#)
- [xiaodong\\_test\\_project\\_for\\_case\\_3391\\_7](#)
- [Zhong Revit File Upgrader Project](#)
- [my\\_test\\_project\\_for\\_case\\_3391\\_12](#)
- [Forge Demo ZW DA](#)
- [xiaodong\\_change\\_project\\_name\\_by\\_API](#)
- [Xiaodong-test-MC](#)
- [Forge Concert Hall](#)
- [my\\_test\\_project\\_for\\_case\\_3391\\_11](#)

Clash Overview

Clash Issue View

Matrix View by Object Count of Active Clash

▲ {3D}\_Audubon\_Architecture.rvt {3D}\_Audubon\_Structure.rvt {3D}\_Audul

{3D}_Audubon_Architecture.rvt		719	216
{3D}_Audubon_Mechanical.rvt	244	91	
{3D}_Audubon_Structure.rvt	324		47

PowerBI Analyze by Object Category and Clash Count

## ModelSets

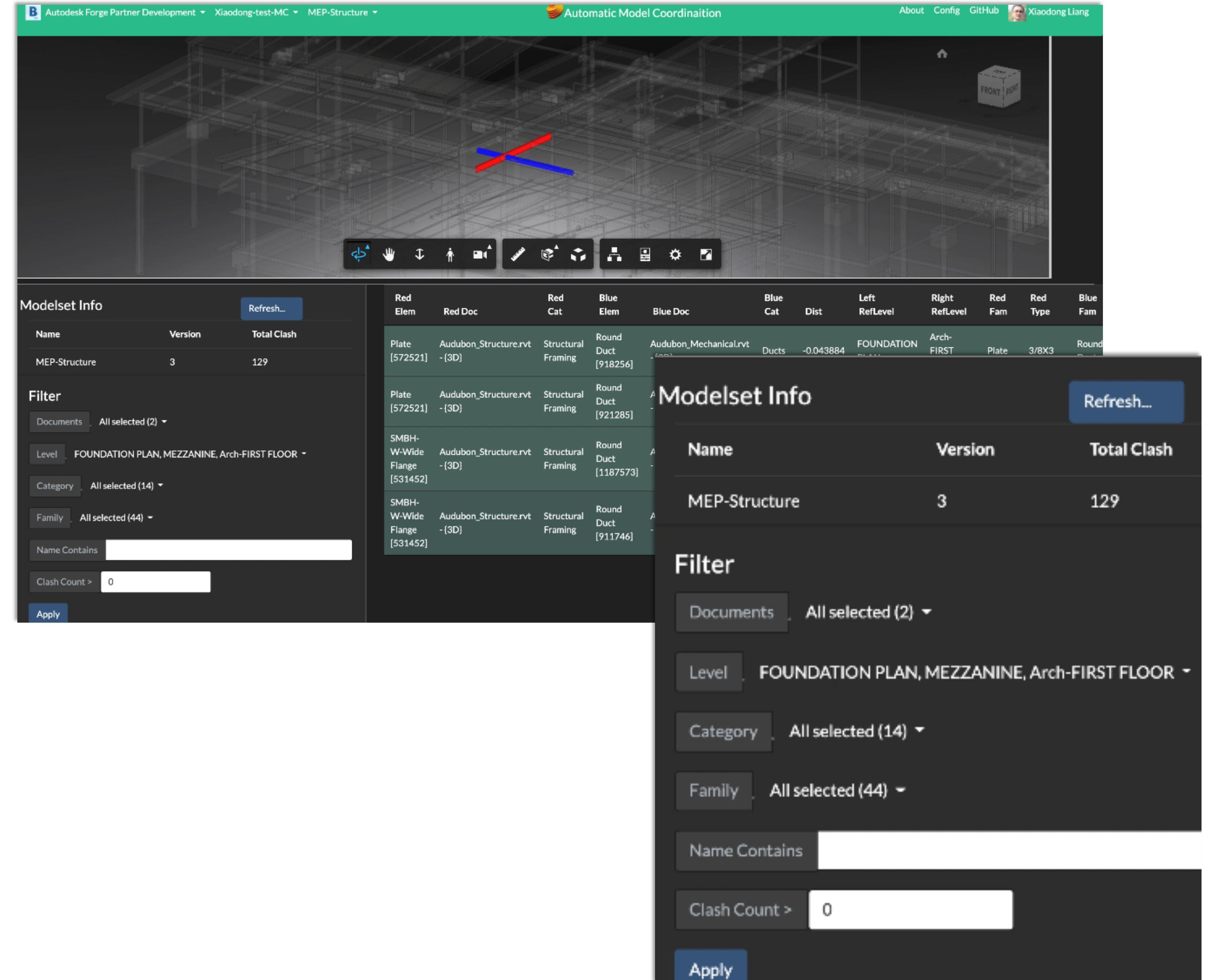
AUDemo	v-2
MC_20190925130256	v-2
MC_20190924075642	v-2
MC_20190829164612	v-2
MC_20190815073143	v-2
MC_20190802142536	v-1
MC_20190802135420	v-0
MC_20190802105545	v-0
xiaodongtest 2019-6-9	v-0

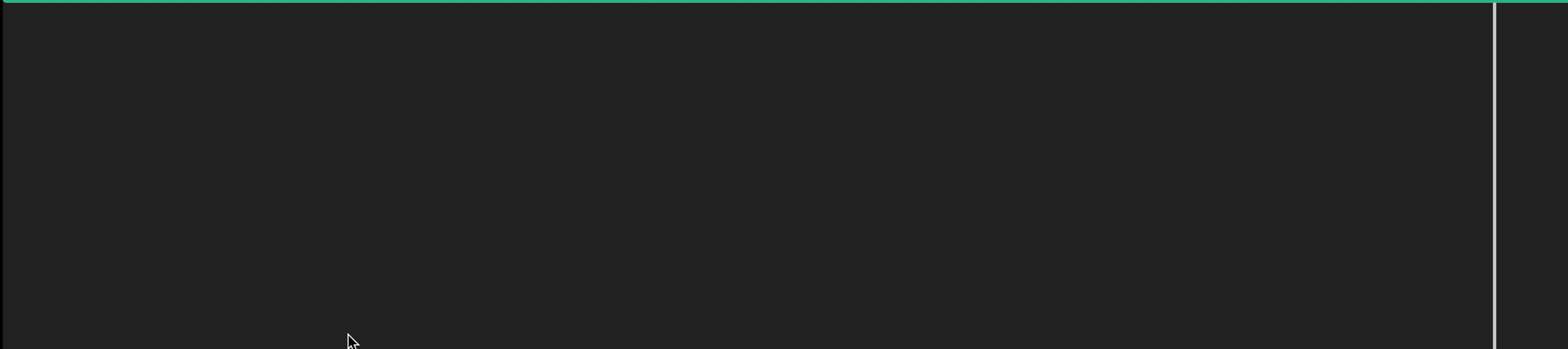
# Filtering by Properties

**What it does:** Filter clashes by levels, element categories, family types, and names.

**Code:** [GitHub Sample](#)

**Author:** Xiaodong Liang, Autodesk





Modelset Info			Refresh...
Name	Version	Total Clash	
MEP-Structure	3	N/A	

Red Elem	Red Doc	Red Cat	Blue Elem	Blue Doc	Blue Cat	Dist	Left RefLevel	Right RefLevel	Red Fam	Red Type	Blue Fam	Blue Type	Room	Clash Id
No data available in table														

### Filter

Documents : None selected ▾

Level : None selected ▾

Category : None selected ▾

Family : None selected ▾

Name Contains :

Clash Count >

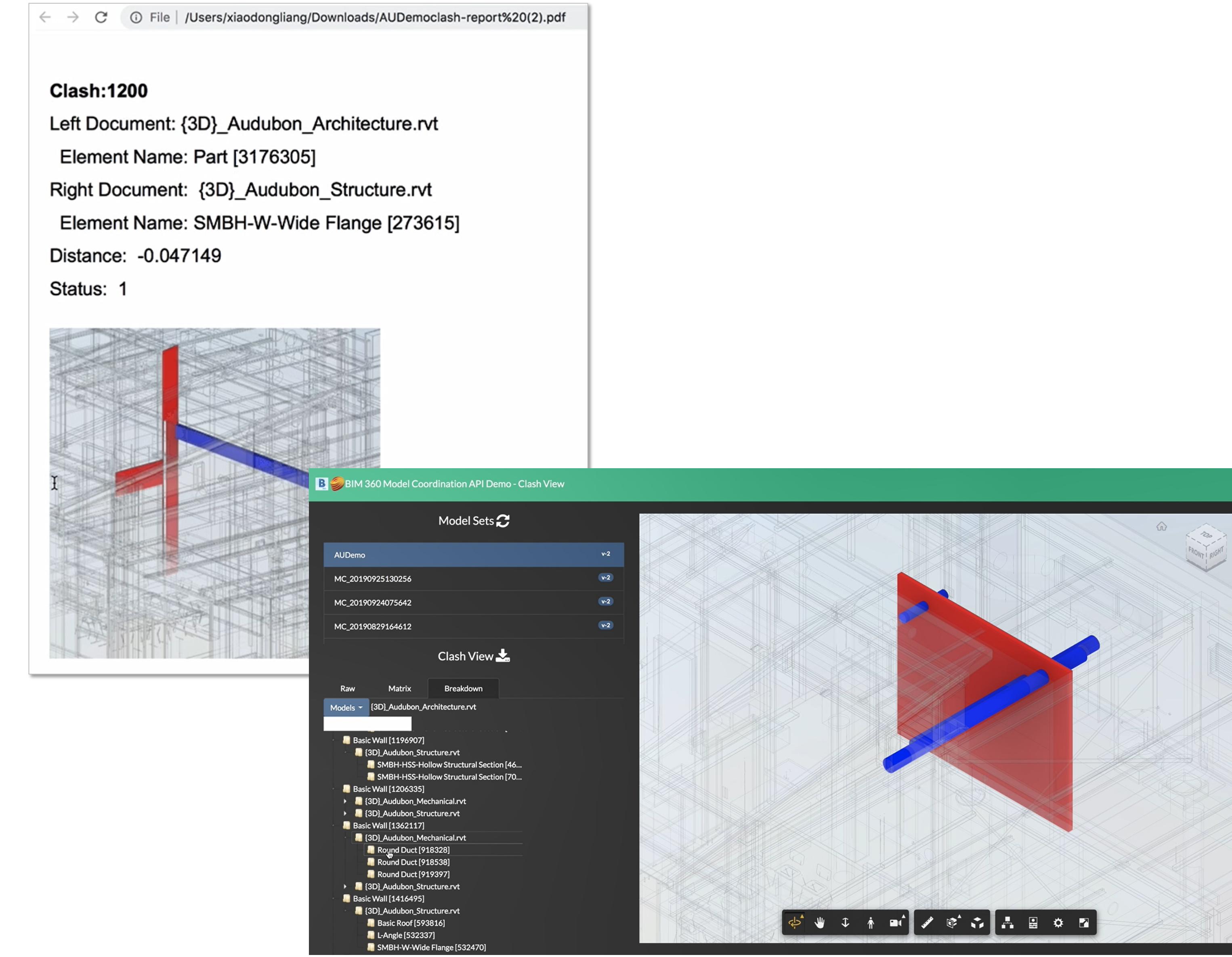
[Previous](#) [Next](#)

# Customized Viewer and Report Generation

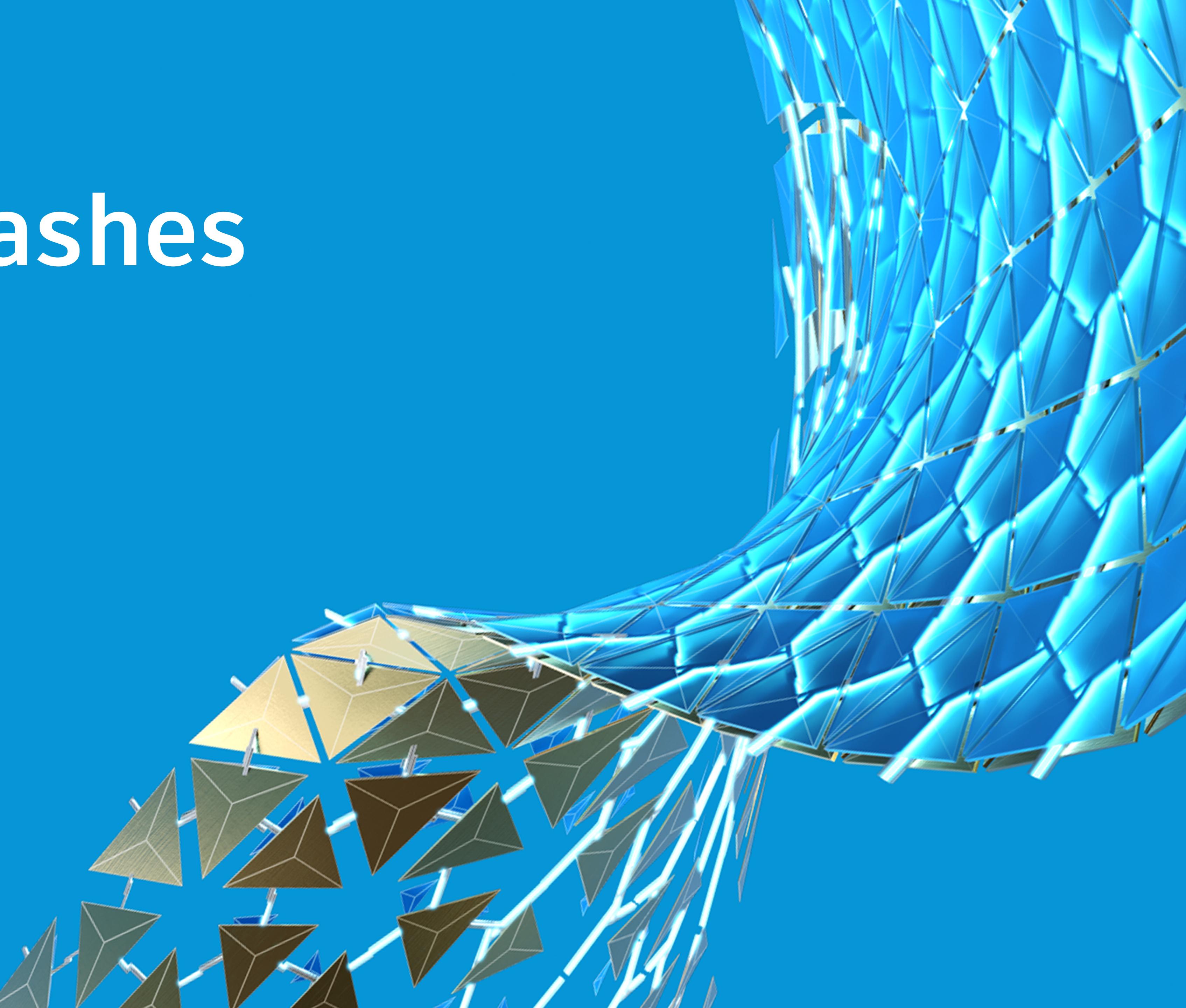
**What it does:** Integrating with the model Viewer create customized report

**Code:** [GitHub Sample](#)

**Author:** Xiaodong Liang, Autodesk



# Solving Clashes



# Solving Clashes

Modify model

Viewer (transient)

Design Automation (can change the model)

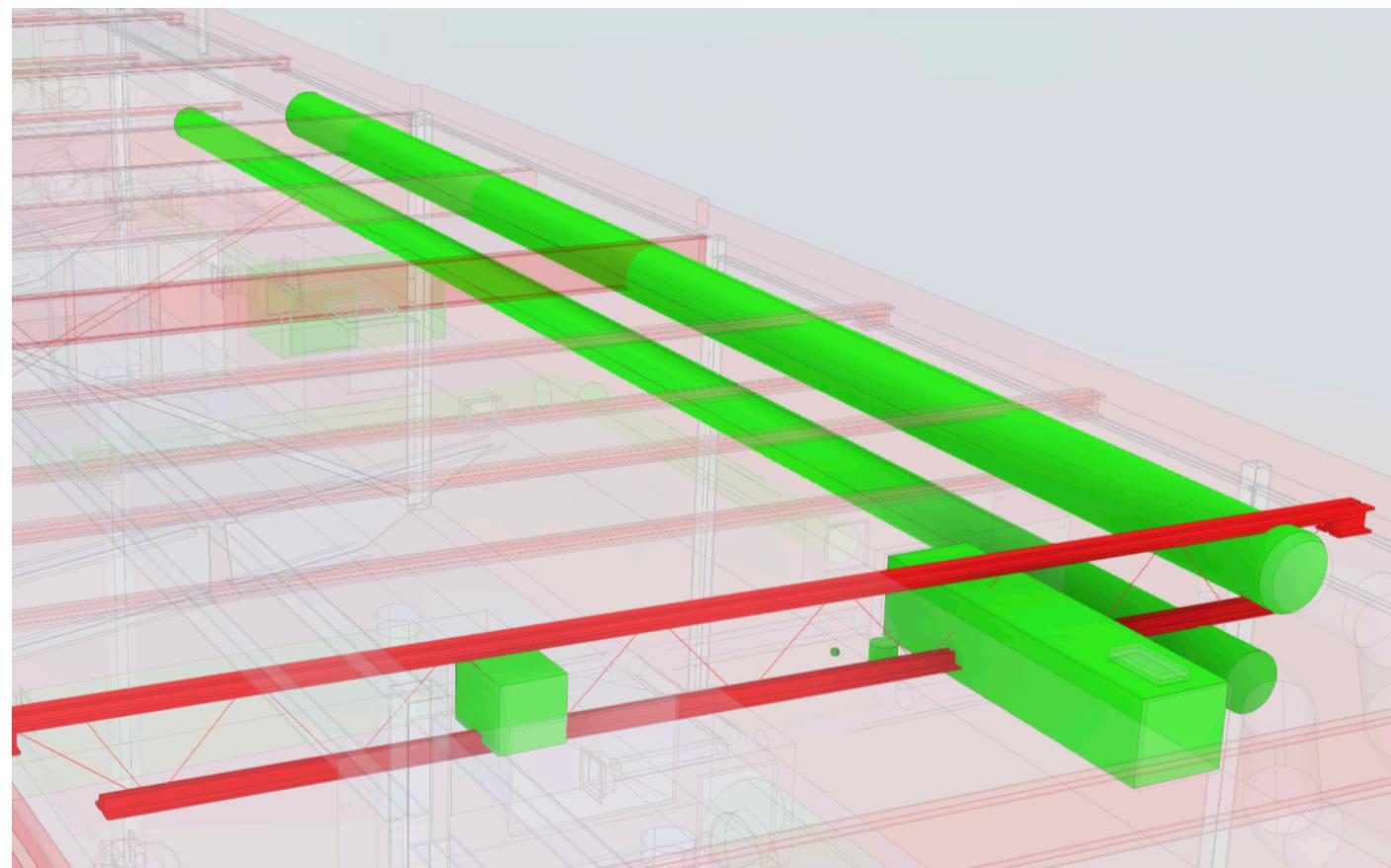
Type of changes

Move up/down/left right

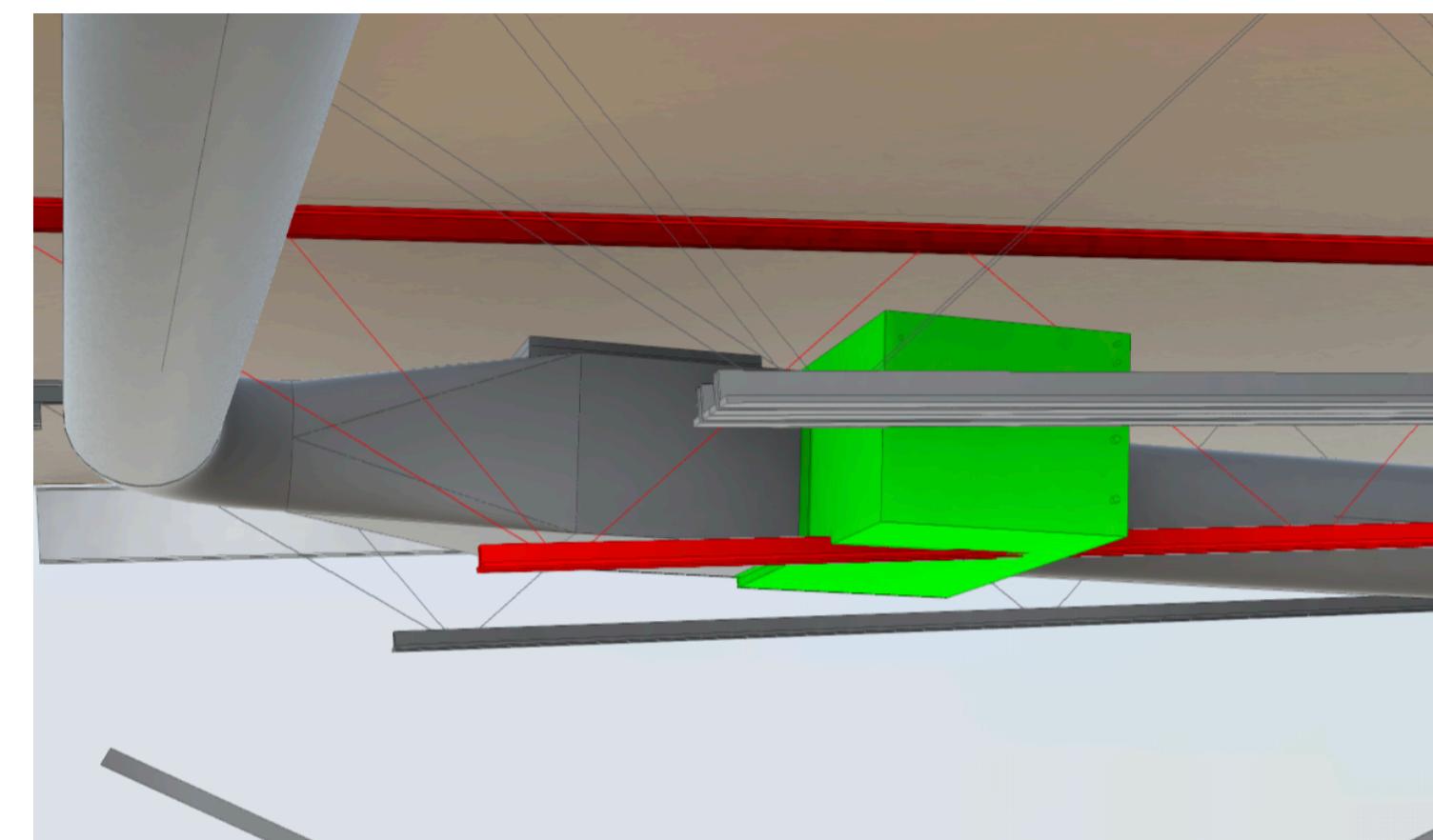
Go around a clash point

MEP objects

# Complex Cases for Automation

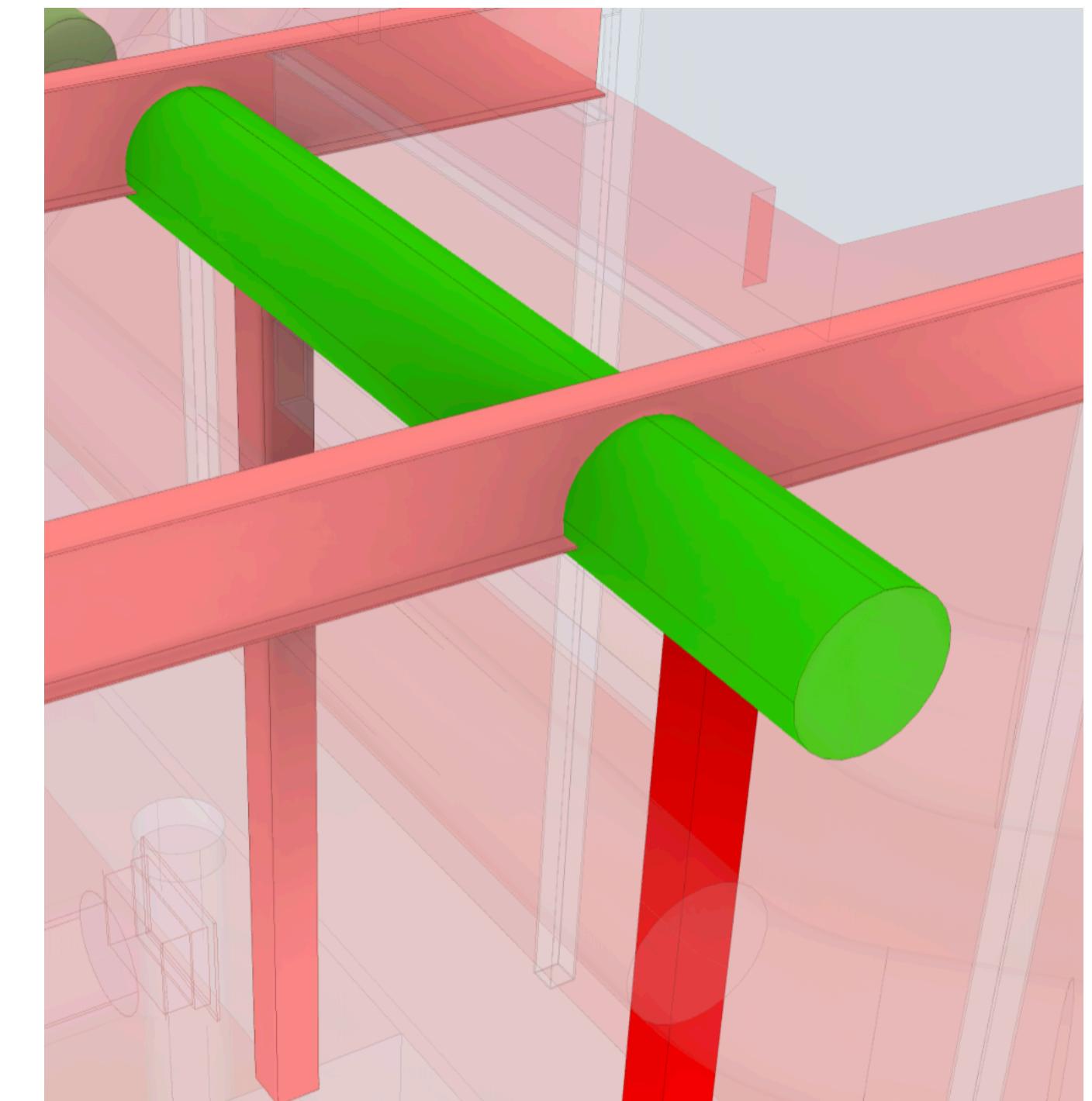


Transfer works only a  
specific direction



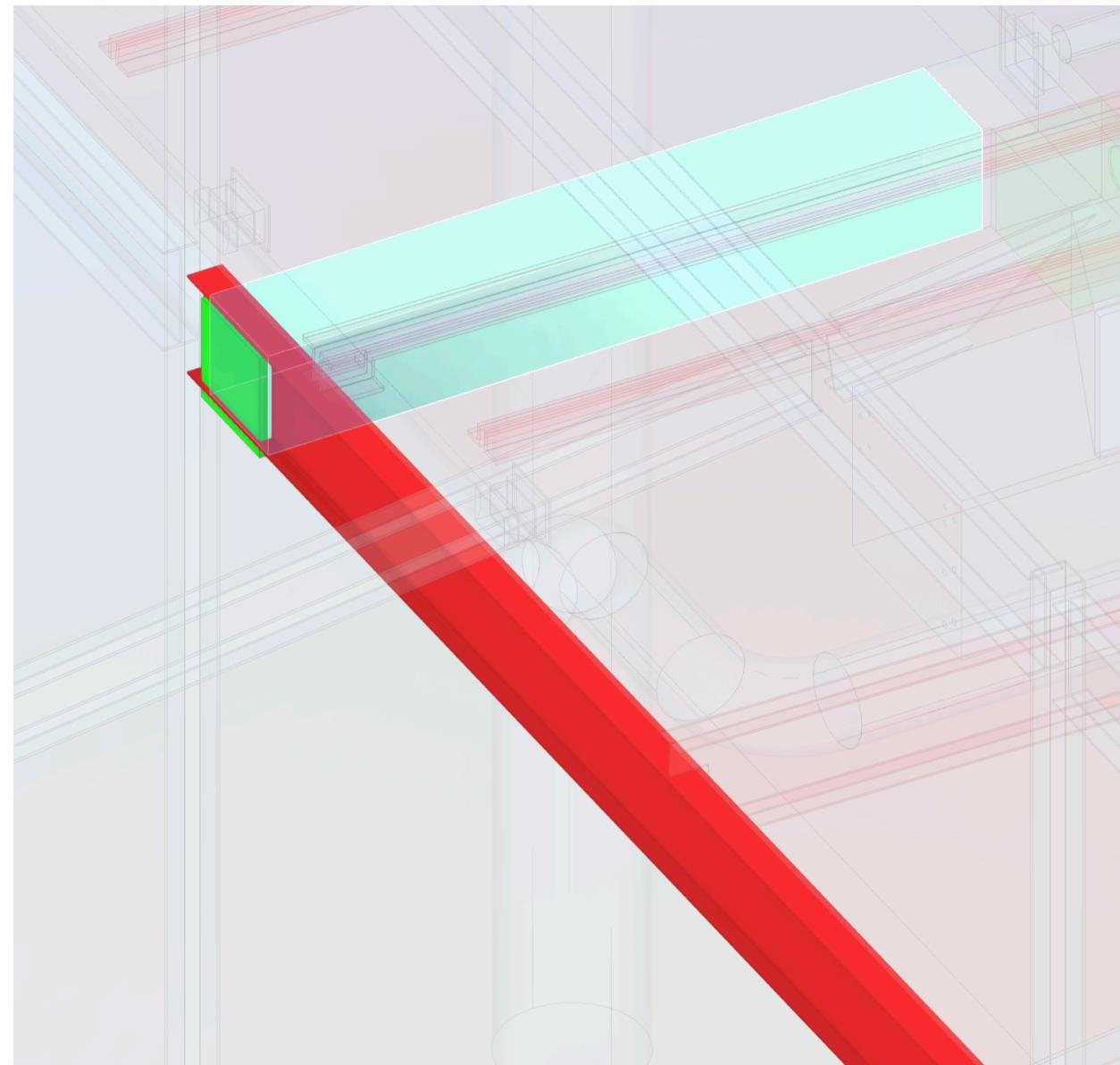
Solving a clash may cause  
new clash

Change of elements will cause connected elements

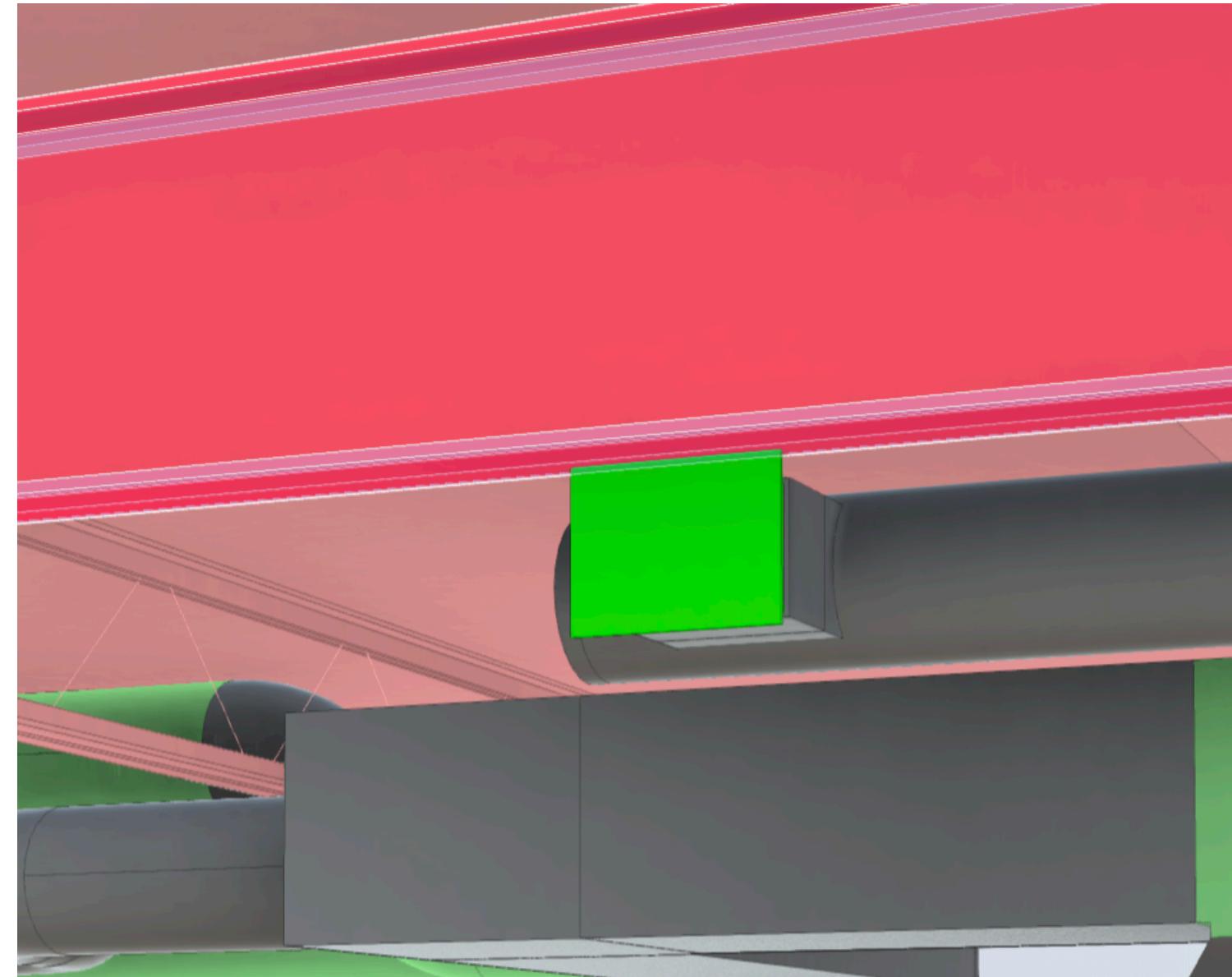


U-shape is not suitable

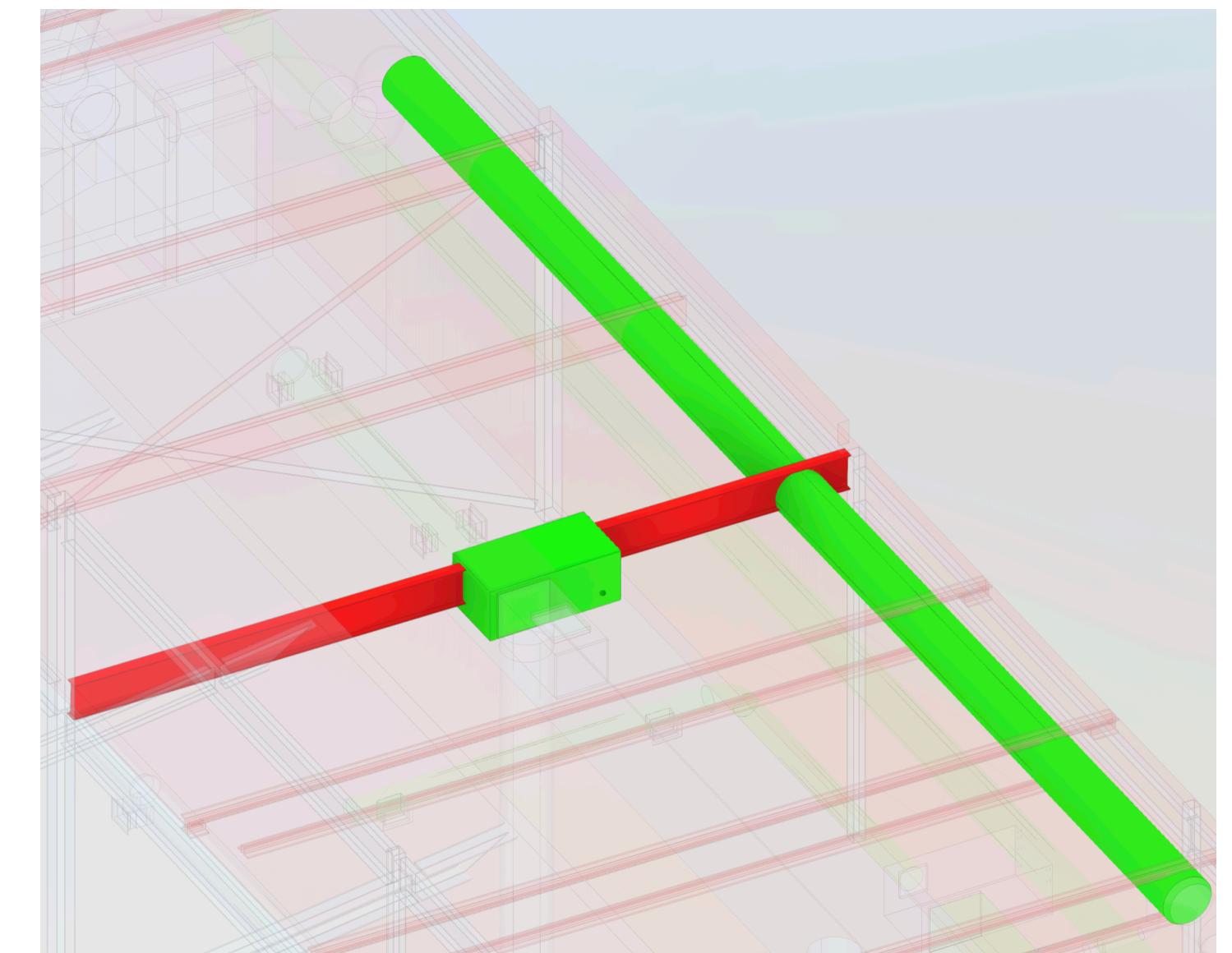
# Simple Cases for Automation



Transfer arbitrary direction



Change family type/size



MEP elements (duct/pipe)  
that can go around (U-  
shape)

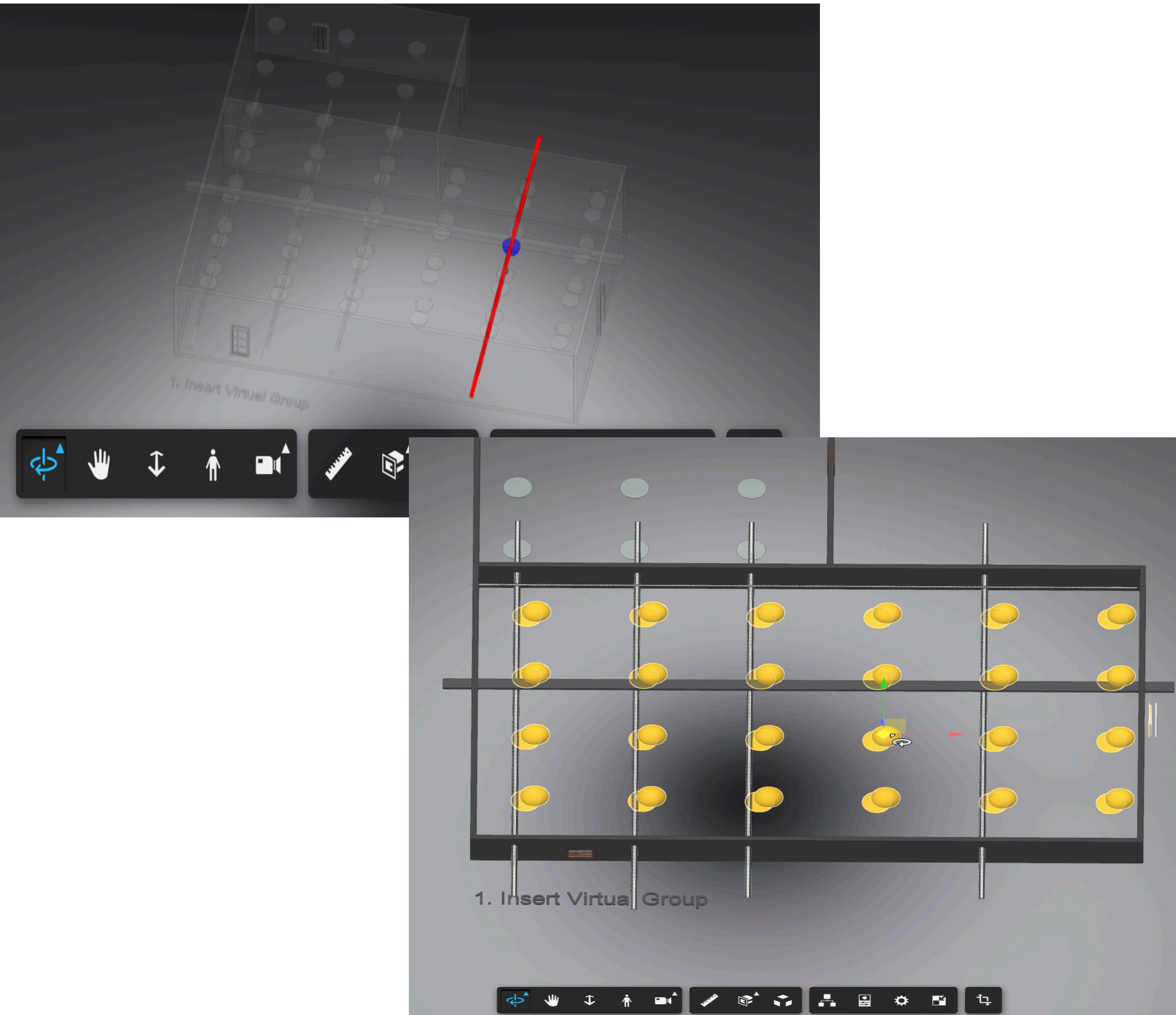
# Solve Clash of Sprinklers with Pipes

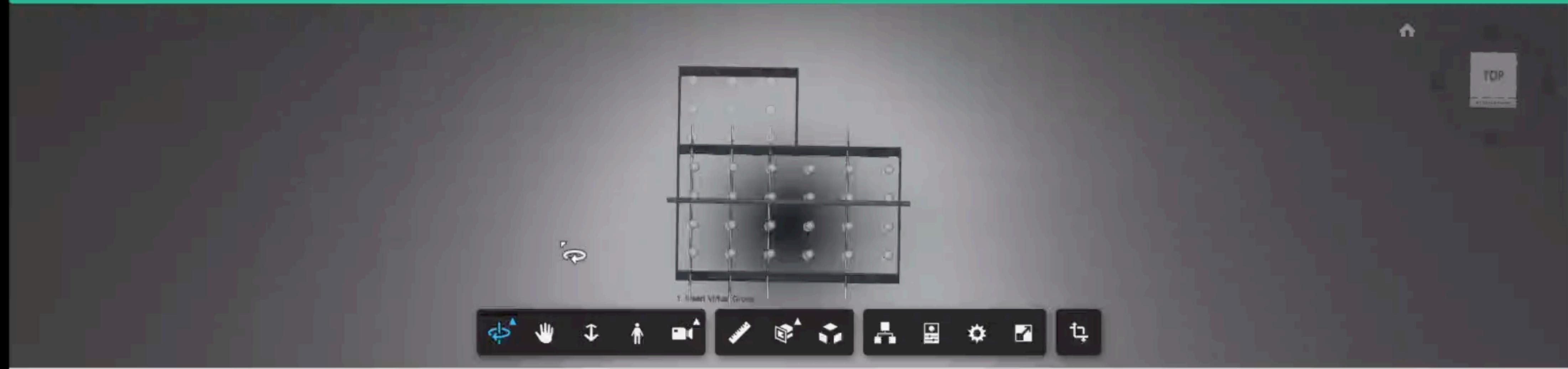
## What it does:

- A group of clashes between sprinklers and pipes (of other MEP system) could be batch resolved.
- Transform tool in Forge Viewer could be a preview on the offset

Code: [GitHub Sample](#)

Author: Xiaodong Liang, Autodesk





## Modelset Info

Refresh... Reload

Tip Version	Total Clash	Fixed Clash
13	27	0

## Filter

Category None selected

Family None selected

Documents None selected

Clash Count > Name Contains 

Apply

Red Elem	Red Doc	Red Cat	Blue Elem	Blue Doc	Blue Cat	Dist	Schema
Pipe Types [773358]	ductrv.rvt -{3D}	Pipes	M_Sprinkler Planning Position Mark [650351]	architecture.rvt -{3D}	Generic Models	-0.023901	Ignore
Pipe Types [773358]	ductrv.rvt -{3D}	Pipes	M_Sprinkler Planning Position Mark [650350]	architecture.rvt -{3D}	Generic Models	-0.025005	Ignore
Pipe Types [773338]	ductrv.rvt -{3D}	Pipes	M_Sprinkler Planning Position Mark [650342]	architecture.rvt -{3D}	Generic Models	-0.025447	Ignore

## Coordination

Posting Work Item.....

Running Work Item.....

Creating New Model Version.....

Creating New Clash ModelSet.....

Creating New Clash Version.....

Downloading Clash Data.....

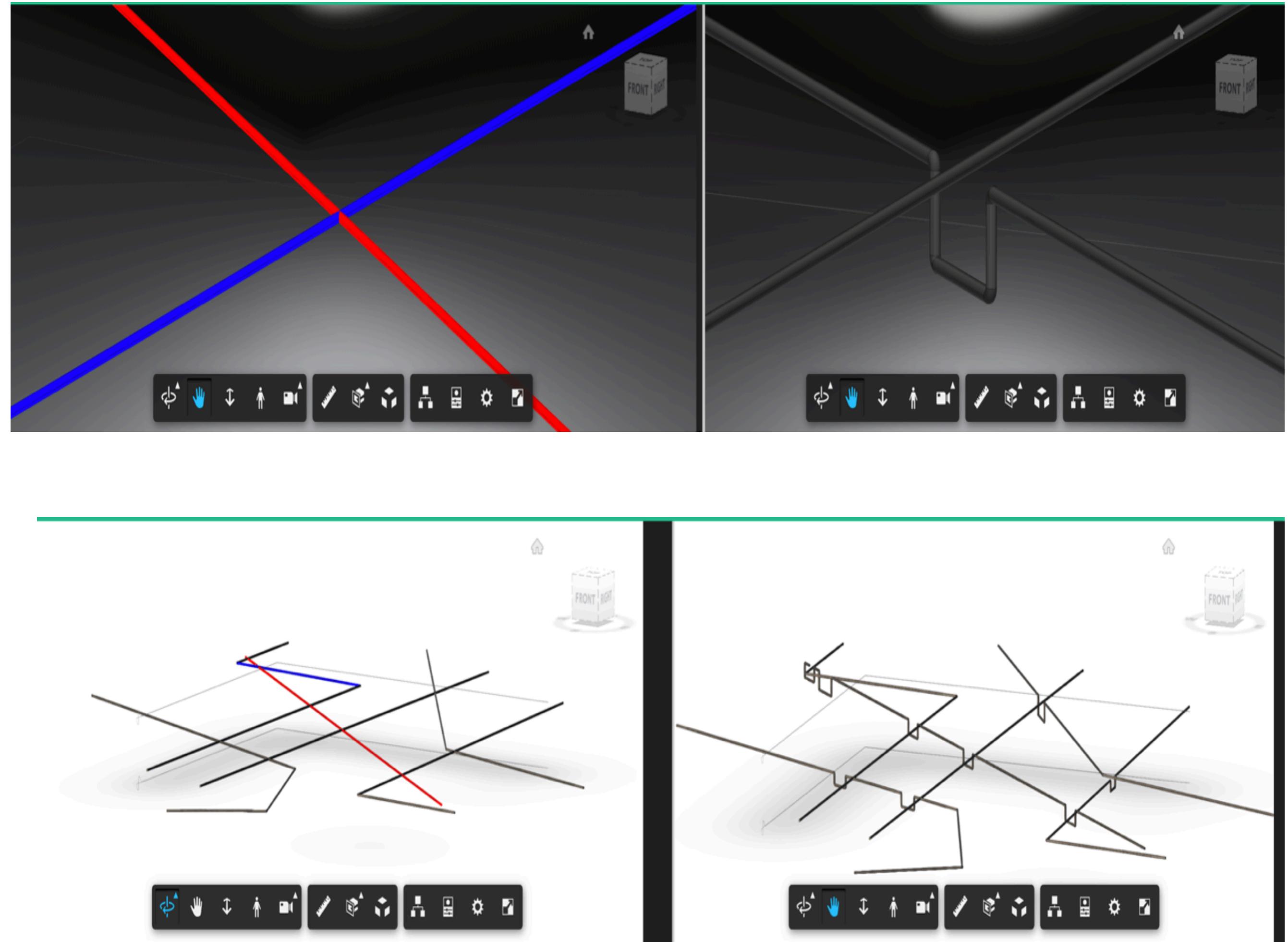
Submit

# Solve Multiple Pipes Obstruction

**What it does:** Two pipes systems, clashed. By automation, some of them can be updated with U type to avoid obstruction, while keep the original connectors of pipe

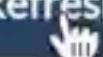
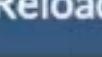
**Code:** [GitHub Sample](#)

**Author:** Xiaodong Liang, Autodesk

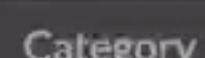


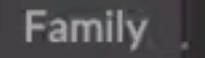
**Modelset Info**

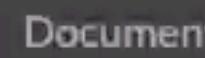
Tip Version: 27    Total Clash: 0    Fixed Clash: 0

Refresh...  Reload 

**Filter**

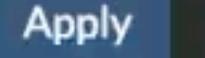
Category: None selected 

Family: None selected 

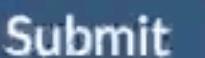
Documents: None selected 

Clash Count >

Name Contains

Apply 

Red Elem	Red Doc	Red Cat	Blue Elem	Blue Doc	Blue Cat	Dist	Schema	Red Fam	Red Type	Blue Fam	Blue Type	Level
No data available in table												

- Coordination**
- Posting Work Item.....
- Running Work Item.....
- Creating New Model Version.....
- Creating New Clash ModelSet.....
- Creating New Clash Version.....
- Downloading Clash Data.....
- Submit 

# Solve Clashes of Duct with Flange

What it does: solve clash by real models of structure and mechanical.

Code: [GitHub Sample](#)

Author: Xiaodong Liang, Autodesk

The screenshot shows a 3D model of a building structure with various pipes and ducts. A blue duct and a red flange are highlighted in red, indicating a collision. The interface includes a top navigation bar with 'Autodesk Forge Partner Development', 'Xiaodong-test-MC', 'MEP-Structure', 'Automatic Model Coordination', 'About', 'Config', 'GitHub', and a user profile. Below the navigation is a toolbar with icons for selection, zoom, and rotation. The main area is divided into two 3D views. The left view shows the initial clash, while the right view shows the resolved state where the blue duct has been modified to fit around the red flange. Below the 3D views is a 'Modelset Info' table:

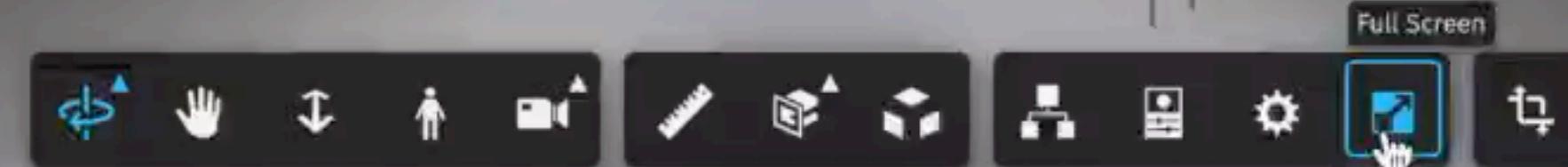
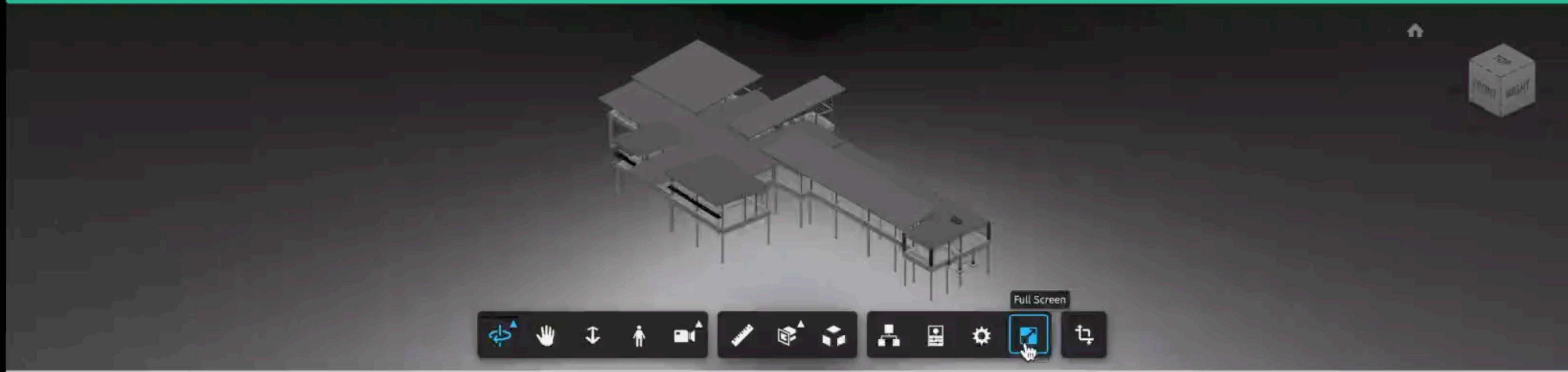
Name	Version	Total Clash	Fixed Clash
MEP-Structure	2	130	0

Below the table is a 'Filter' panel with categories for 'Category' (Ducts, Duct Fittings), 'Family' (All selected (44)), 'Name Contains' (Flange), 'Documents' (All selected (2)), 'Clash Count' (0), and a checkbox for 'Ignore Clash with Duct which Diameter Less than 0.01 meter'. At the bottom are 'Apply' and 'Submit' buttons. To the right is a 'Coordination' sidebar with a list of tasks:

- Posting Work Item.....
- Running Work Item.....
- Creating New Model Version.....
- Creating New Clash ModelSet.....
- Creating New Clash Version.....
- Downloading Clash Data.....

At the bottom are 'Previous' and 'Next' buttons.





## Modelset Info

Refresh... Reload

Tip Version	Total Clash	Fixed Clash
10	130	0

## Filter

Category None selected

Family None selected

Documents None selected

Clash Count > Name Contains 

Apply

Red Elel	Red Doc	Red Cat	Blue Elel	Blue Doc	Blue Cat	Dist	Schema
LH-Series Bar Joist quarterspan [575377]	Audubon_Structure.rvt -{3D}	Structural Framing	Round Duct [918318]	Audubon_Mechanical.rvt -{3D}	Ducts	-0.00434	Ignore
LH-Series Bar Joist quarterspan [446839]	Audubon_Structure.rvt -{3D}	Structural Framing	Round Transition - Angle [853114]	Audubon_Mechanical.rvt -{3D}	Duct Fittings	-0.004635	Ignore
SMBH-W- Wide Flange [261987]	Audubon_Structure.rvt -{3D}	Structural Framing	Heat Pump - Horizontal - Water Source - Back Discharge [903488]	Audubon_Mechanical.rvt -{3D}	Mechanical Equipment	-0.005991	Ignore

## Coordination

Posting Work Item.....

Running Work Item.....

Creating New Model Version.....

Creating New Clash ModelSet.....

Creating New Clash Version.....

Downloading Clash Data.....

Previous

Submit

# Developer Tools Behind



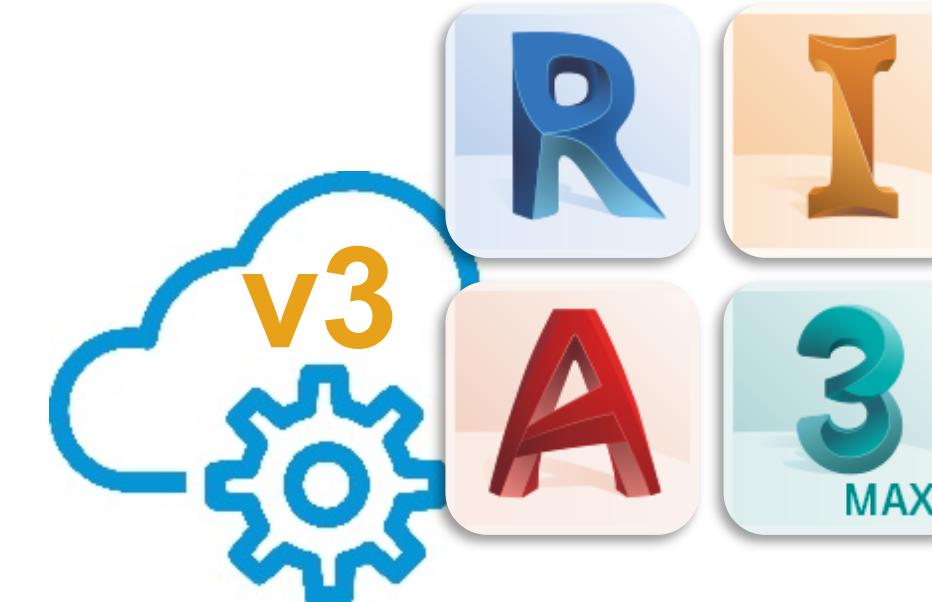
# Forge



Authentication



Data Management



Design Automation



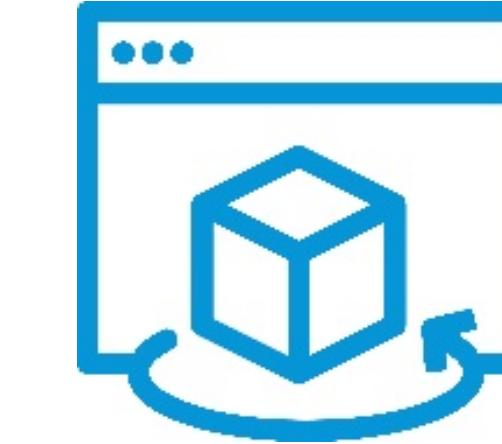
BIM 360



Reality Capture



Model Derivatives

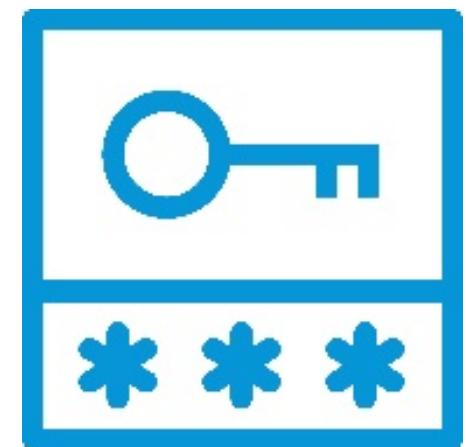


Viewer



Webhooks

# Forge



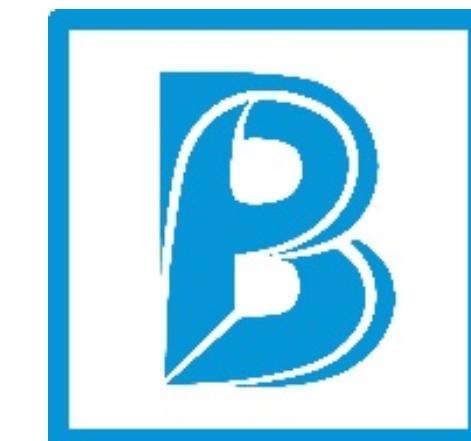
Authentication



Data Management



Design Automation



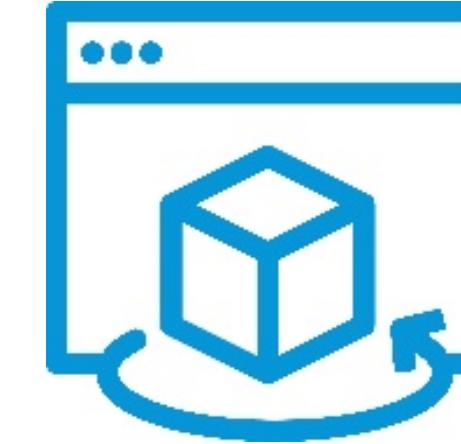
BIM 360



Reality Capture



Model Derivatives

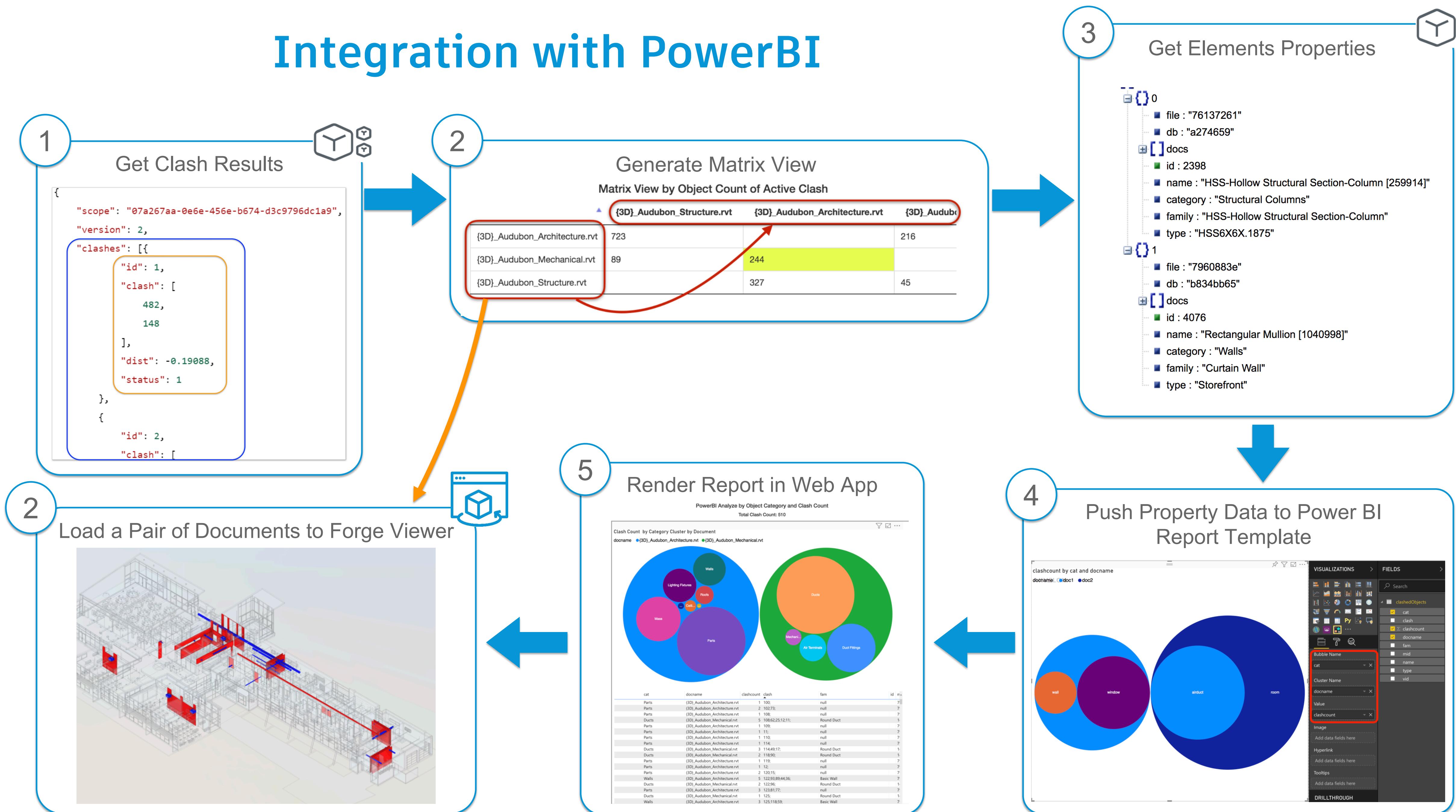


Viewer

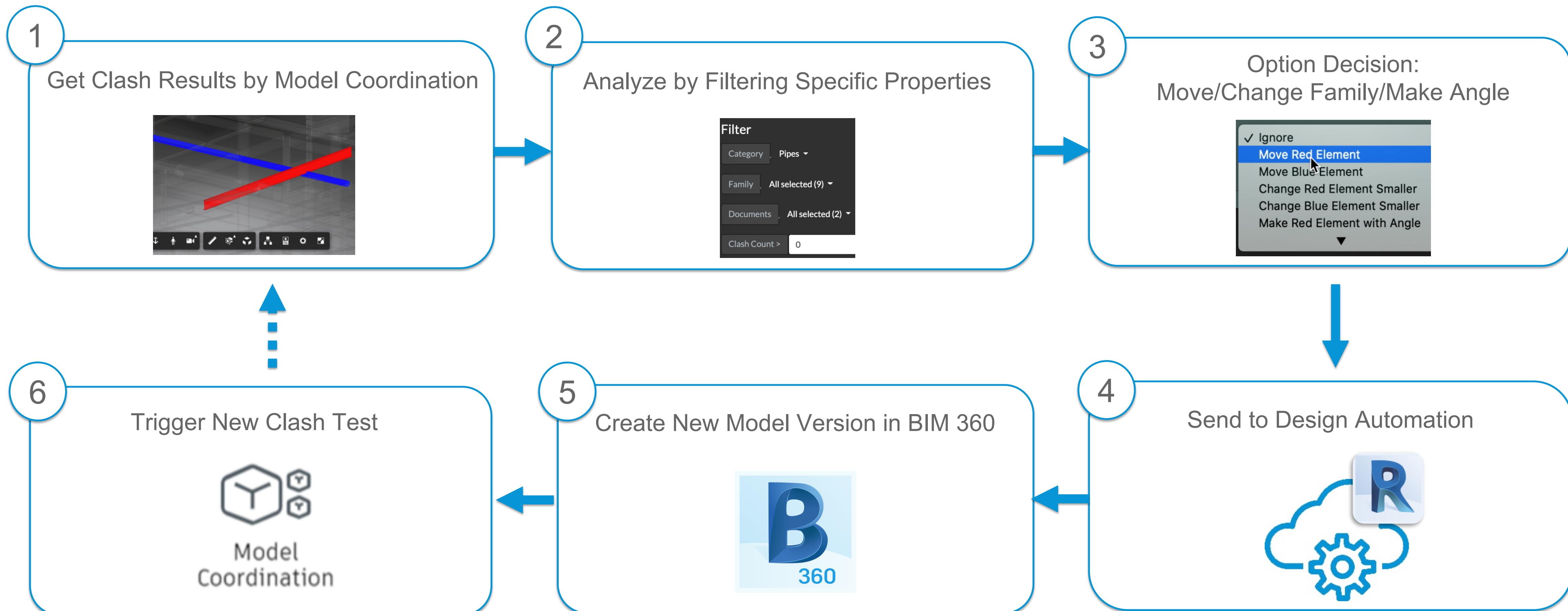


Webhooks

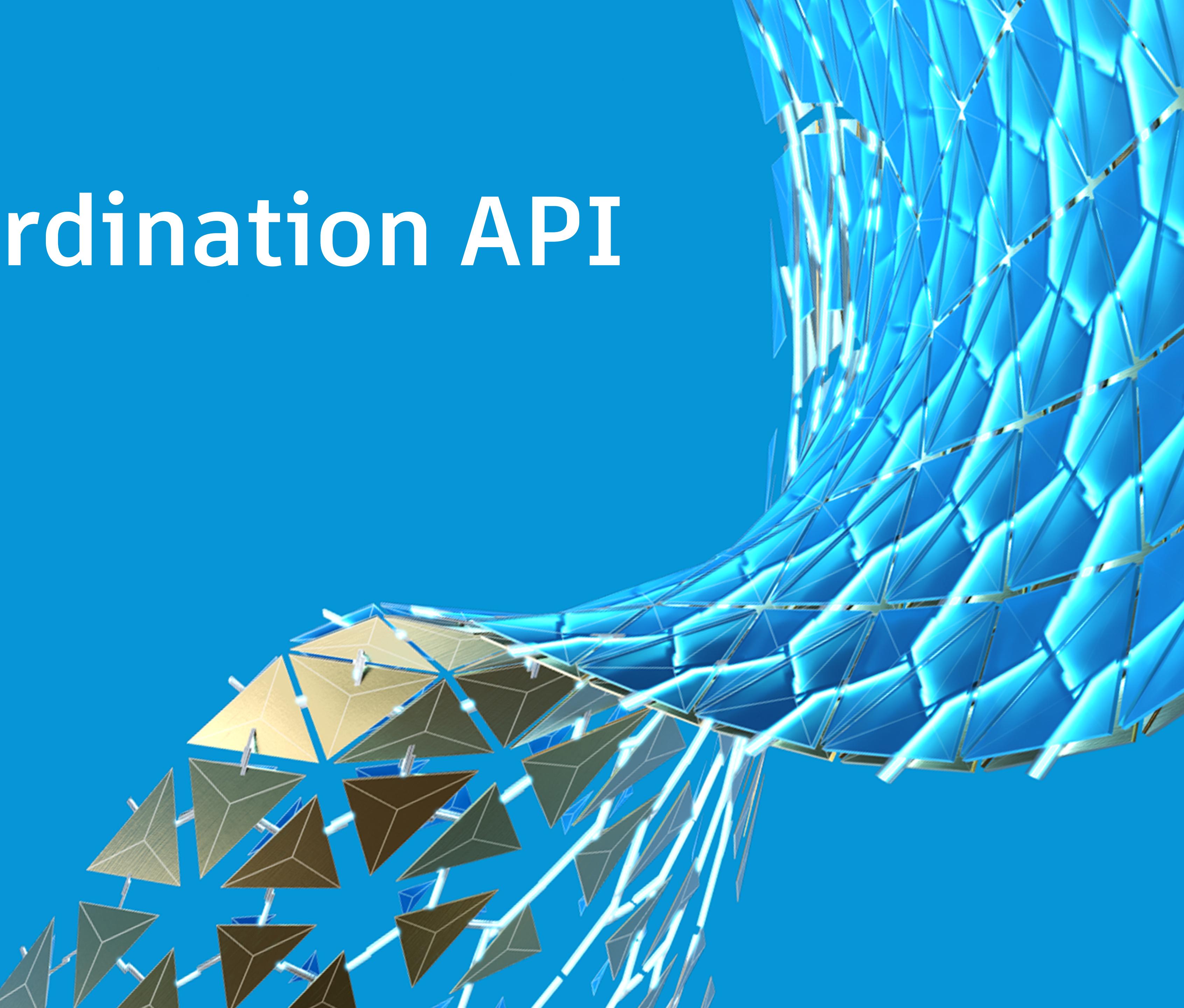
# Integration with PowerBI



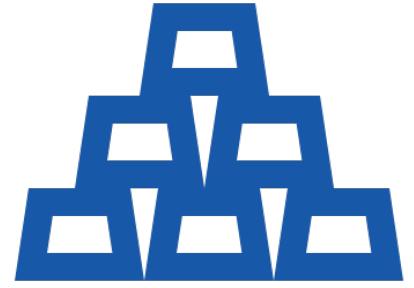
# Integration with Design Automation for Revit



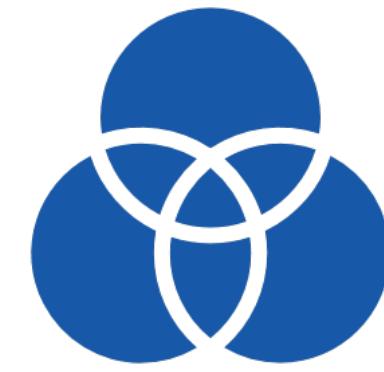
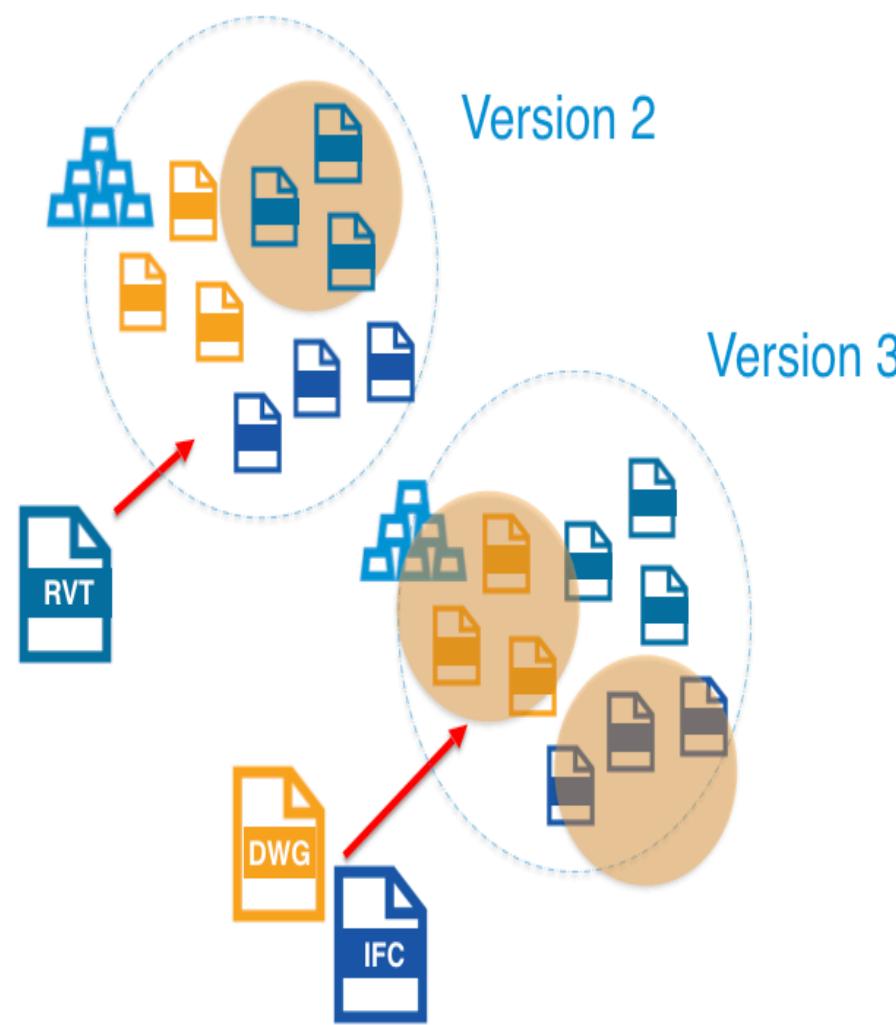
# Model Coordination API



# Model Coordination API



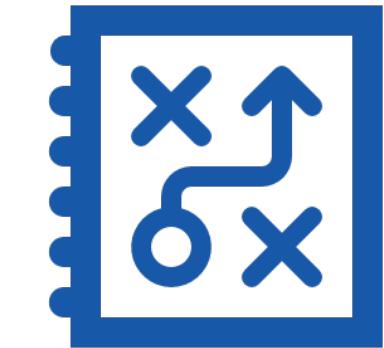
Model set  
versions  
through time



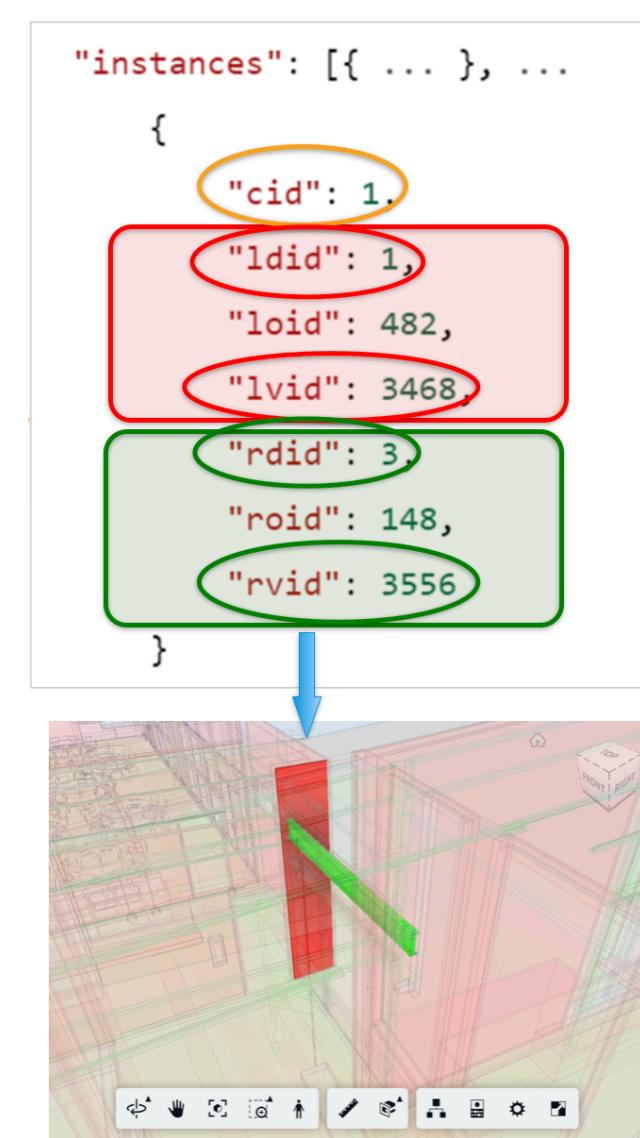
Clash tests for  
every model set  
version



BIM index properties  
for every model set  
version



Closed and Assigned  
(Issue) Clash Groups

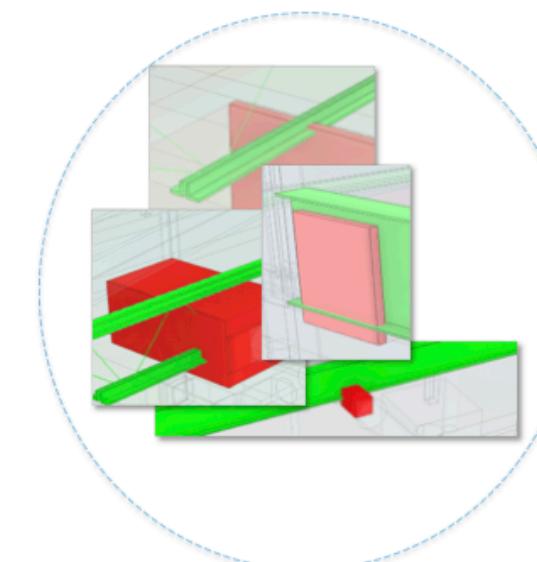


SQL Indexing



SELECT \* WHERE ...

```
{"file": "d8e674e7", "db": "3ff9dee3",  
"docs": ["8e525582"], "id": 2236, "Level":  
"Arch-FIRST FLOOR", "Average Estimated  
Illumination": 0.0,  
"Room Name": "Unoccupied", "Area": 0.0,  
"name": "WOMEN'S TOILET 131 [715139]",  
"Volume":  
0.0, "Plenum": false, "Computation  
Height": 4.0, "Specified Exhaust  
Airflow": 0.0, "_RC": "Spaces", "Calculated  
Heating Load":
```



```
{  
"groups": [  
{  
"id": "0e348635-6bcecb3d",  
"clashTestId": "3fa85f64-2c9636",  
"issueId": "4a7cbba7-576330aca190",  
"createdBy": "HJOOJSDiiUS",  
"createdOn": "2019-10-10T",  
"clashes": [1, 93, 1883, 36, 92]  
},  
...  
]
```



## Clash

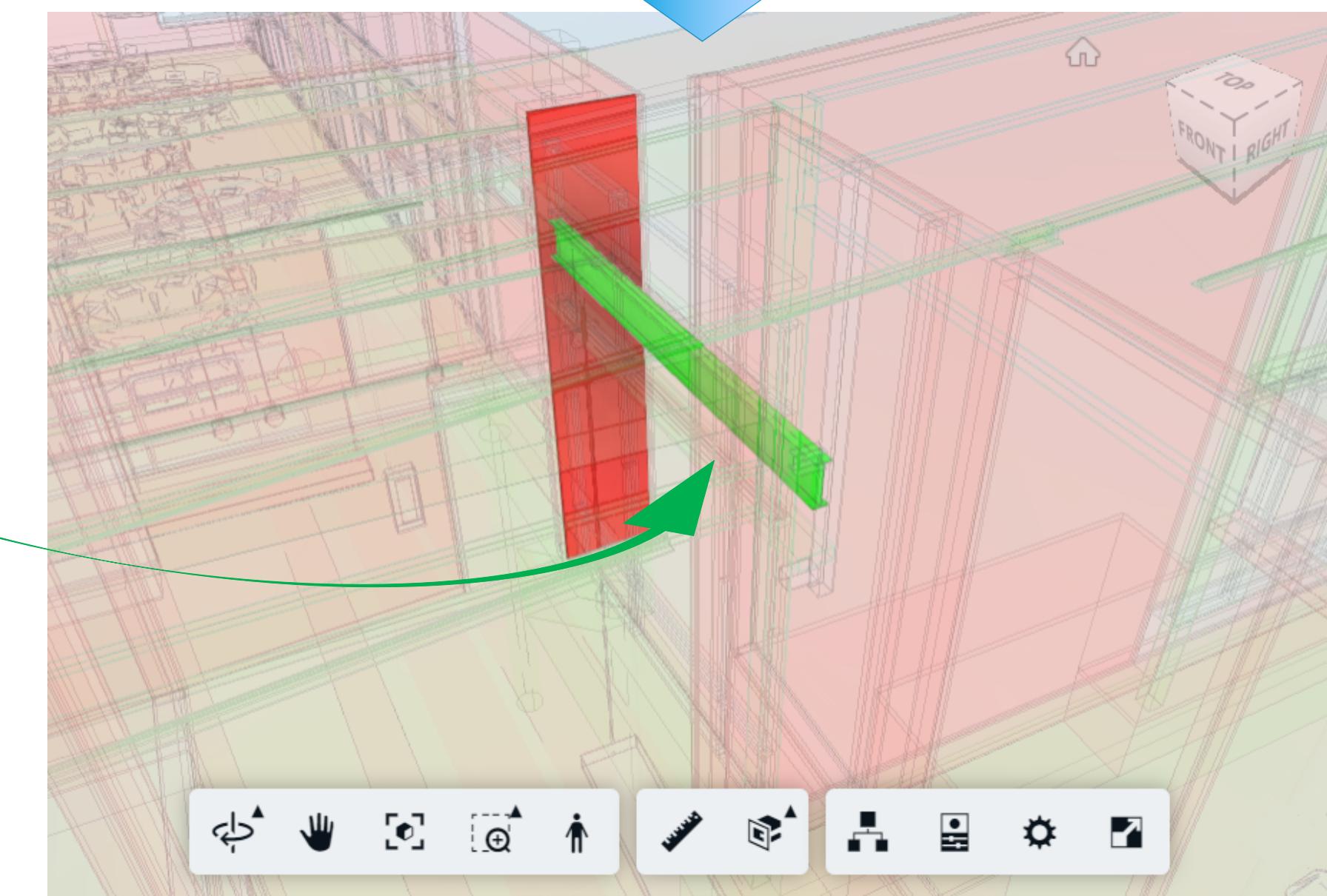
```
"clashes": [{"id": 1, "clash": [482, 148], "dist": -0.19088, "status": 1}],
```

## Clash Instance

```
"instances": [{"cid": 1, "ldid": 1, "loid": 482, "lvid": 3468}, {"rdid": 3, "roid": 148, "rvid": 3556}]
```

## Documents Manifest

```
"documents": [{"id": 1, "urn": "urn:adsk.wipprod:fs.file:vf.LX405vtjSne2MkGwjLIwQA?version=1"}, {"id": 2, "urn": "urn:adsk.wipprod:fs.file:vf.o0wETj03RmSyap1fhcW9bQ?version=1"}, {"id": 3, "urn": "urn:adsk.wipprod:fs.file:vf.pa8ursEARQiv0-4IbByznQ?version=1"}]
```



# SQL Indexing

Index per Model Set Version of **ALL** available BIM data

Backed by **AWS S3 Select** supports:-

SELECT ... FROM ... WHERE ... LIMIT

AND, NOT, OR, BETWEEN, IN, Comparison (=, >=..)

Functions...

Aggregate: AVG, SUM, MAX, MIN, COUNT

Conditional: COALESCE, NULLIF

Conversion: CAST

Date & String: DATE\_DIFF, TRIM, UPPER etc..



**SELECT \* WHERE ...**

## Properties Field Manifest

```
{  
  "key": "p07d2c9bb",  
  "category": "Mechanical - Flow",  
  "type": 3,  
  "name": "Velocity Pressure",  
  "uom": "inch water"  
}  
  
{  
  "key": "p0aef9df9",  
  "category": "Mechanical - Flow",  
  "type": 3,  
  "name": "Reynolds number",  
  "uom": null  
}  
  
{  
  "key": "p875a6521",  
  "category": "Dimensions",  
  "type": 20,  
  "name": "Size",  
  "uom": null  
}
```

## Properties Value

```
{  
  "file": "2edba34f",  
  "db": "b834bb65",  
  "docs": [  
    "cf7900d3",  
    "bfe04eff"  
  ],  
  "id": 8074,  
  "name": "Chair-Tablet Arm [1673054]",  
  "cat": "Revit Furniture",  
  "fam": "Chair-Tablet Arm",  
  "typ": "Chair-Tablet Arm"  
}  
  
{  
  "file": "2edba34f",  
  "db": "b834bb65",  
  "docs": [  
    "cf7900d3",  
    "bfe04eff"  
  ],  
  "id": 8075,  
  "name": "Chair-Tablet Arm [1673055]",  
  "cat": "Revit Furniture",  
  "fam": "Chair-Tablet Arm",  
  "typ": "Chair-Tablet Arm"  
}
```

# Model Coordination API

- [AU 2019 Class BIM 360 API Update \(with Model Coordination API introduction\)](#)
- [Model Coordination API lighting talk](#)
- [Model Coordination API tutorial](#)
- [Practice tricks and tips with PowerBI & Model Coordination API](#)
- [Basic Clash View by Model Coordination API in Node.js](#)
- [Walkthrough sample of Model Coordination API in NetCore](#)
- [Postman Collections for Model Coordination API](#)

# Available and Unavailable Data by Model Coordination API

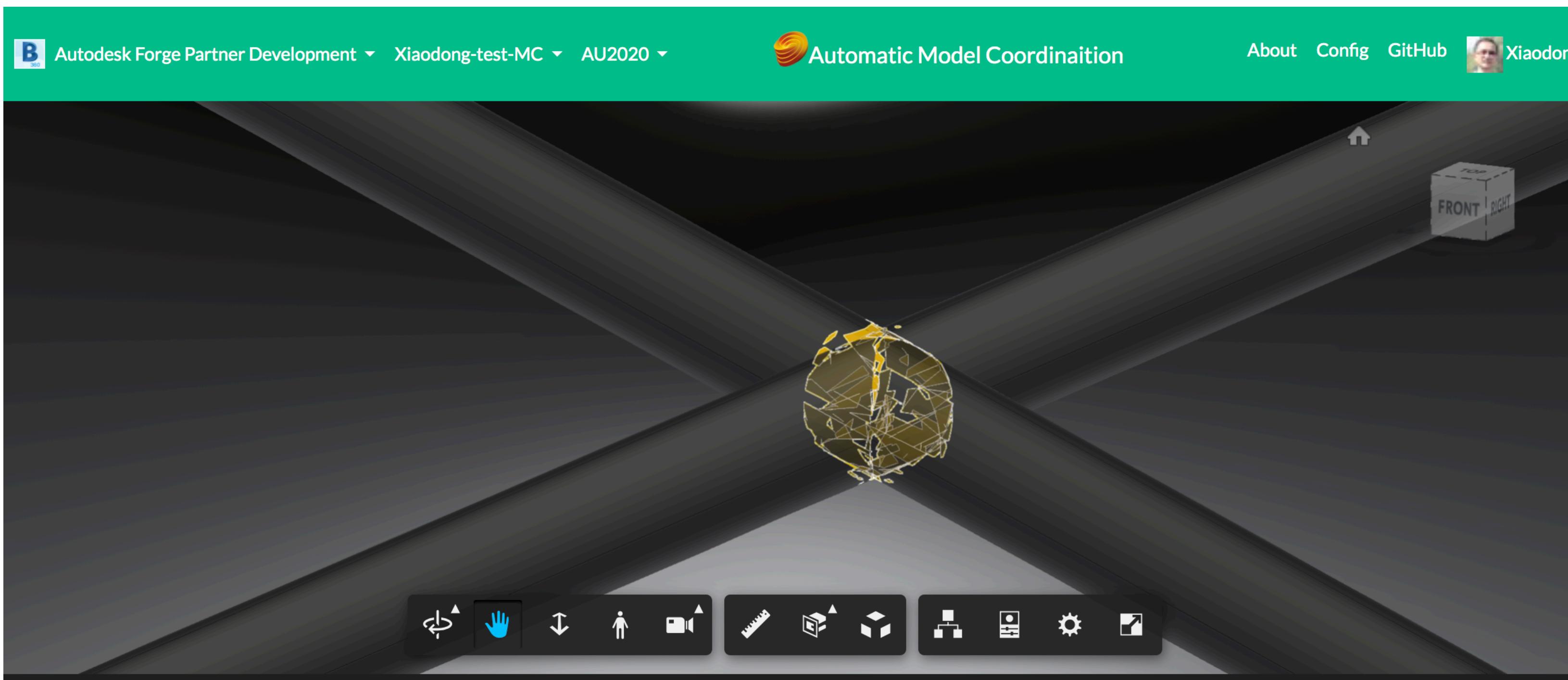
- Ids of clashed elements(db id/ external id)
- Element properties
- Document ids
- Clash distance
- Clash center
- Clash range(box)
- Shortest direction to resolve clash
- Webhook

Available

Unavailable

# Calculation of Clash Center and Range

- With mesh data of Forge Viewer API (fragments vertices)
- Intersection of elements mesh (by THREE.js CSG)
- Balance between precise and performance (CSG tolerance)



# Process Time

Majority is time of notifications

- **A little time:** prepare parameters, create storage for new version file, post item



## Coordination

C Posting Work Item.....

- **Reasonable time:** running workitem, depending on internet connection between Forge and source/target storage, and volume of elements to update.



C Running Work Item.....

- **Quick time:** create new version file in BIM360 folder



C Creating New Model Version.....

- **Longer time:** depending on when version:update of folder notifies model-set to run new coordination.



C Creating New Clash ModelSet.....

- **Longer time:** depending on when model coordination notifies a clash test is done.



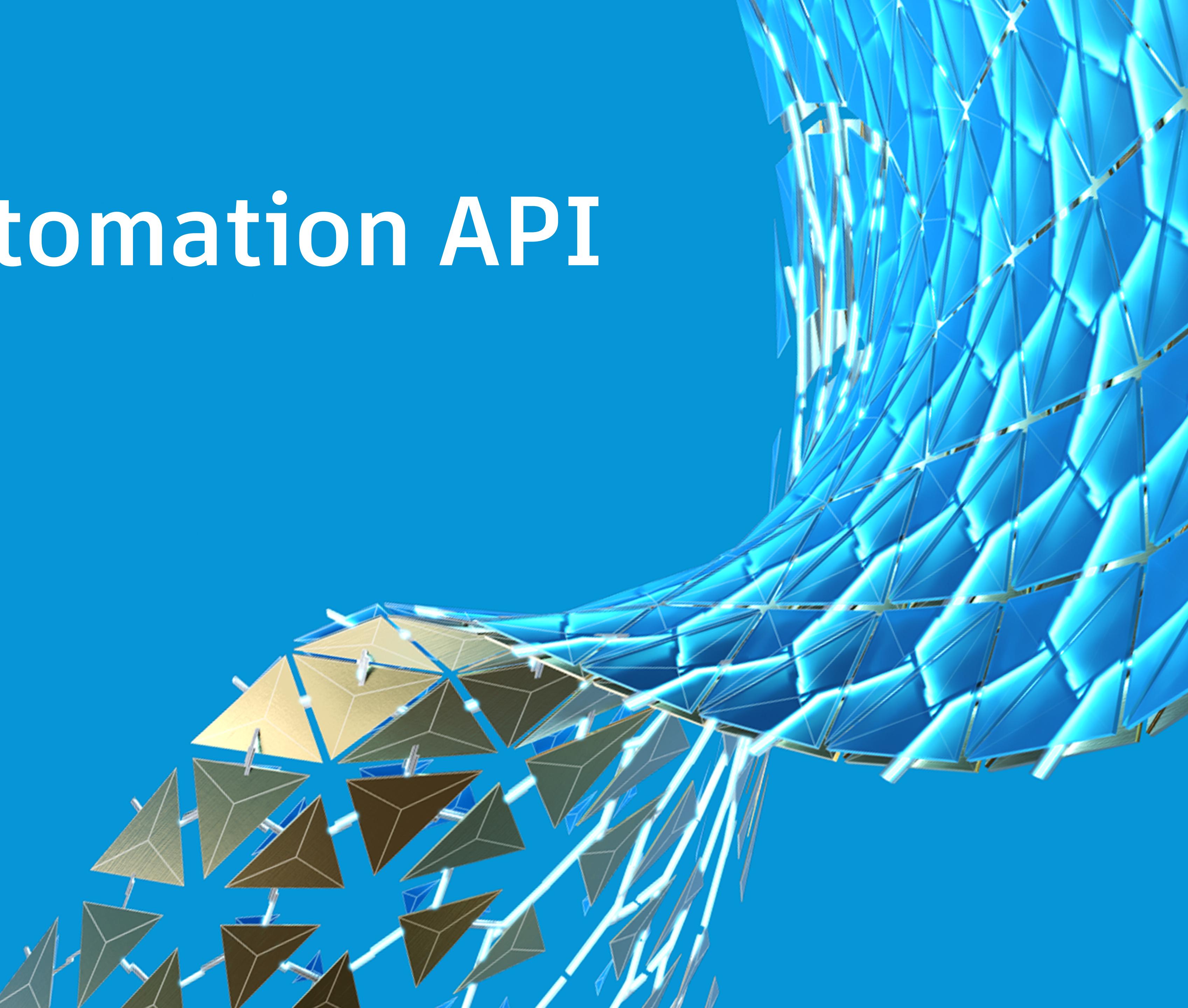
C Creating New Clash Version.....

- **Reasonable time,** download clash raw data and index properties, depending on data volume.

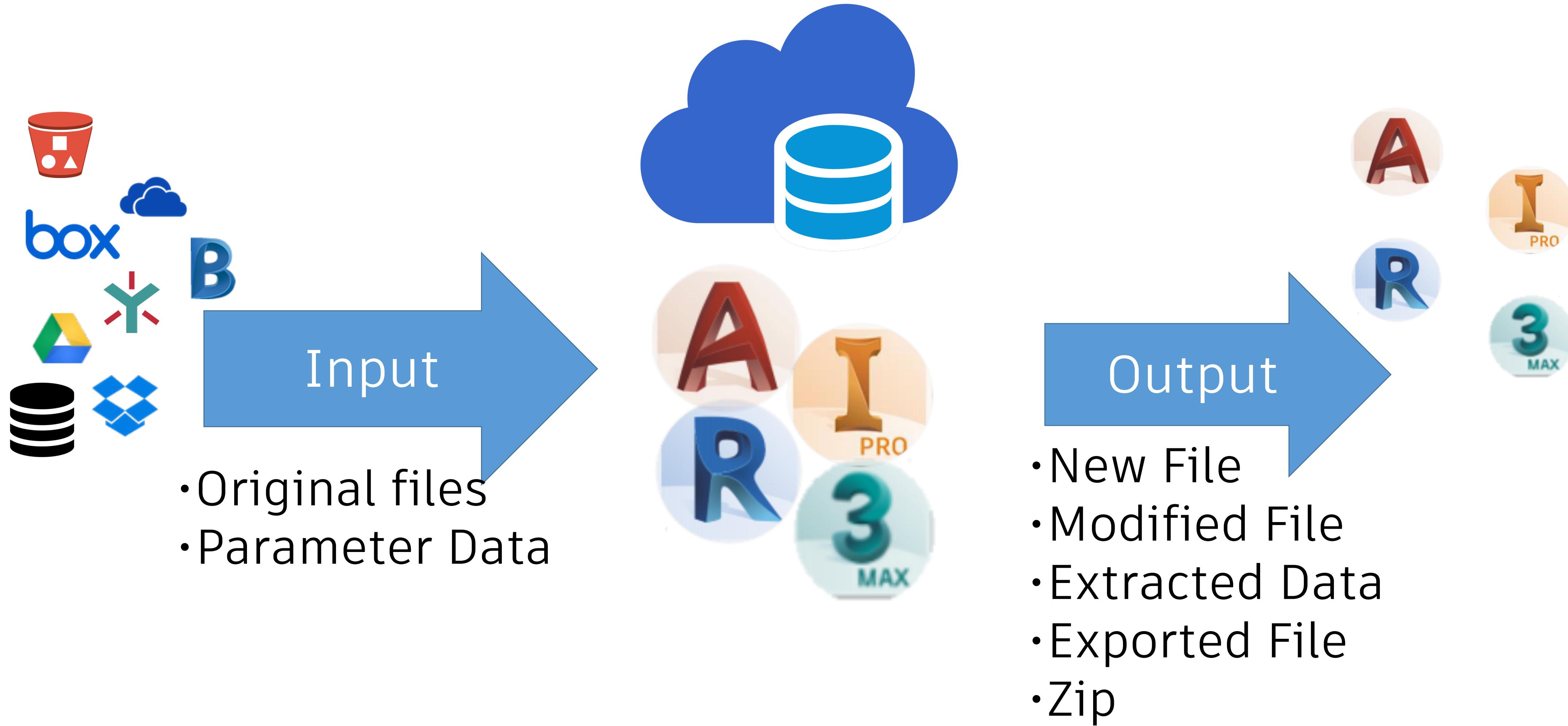


C Downloading Clash Data.....

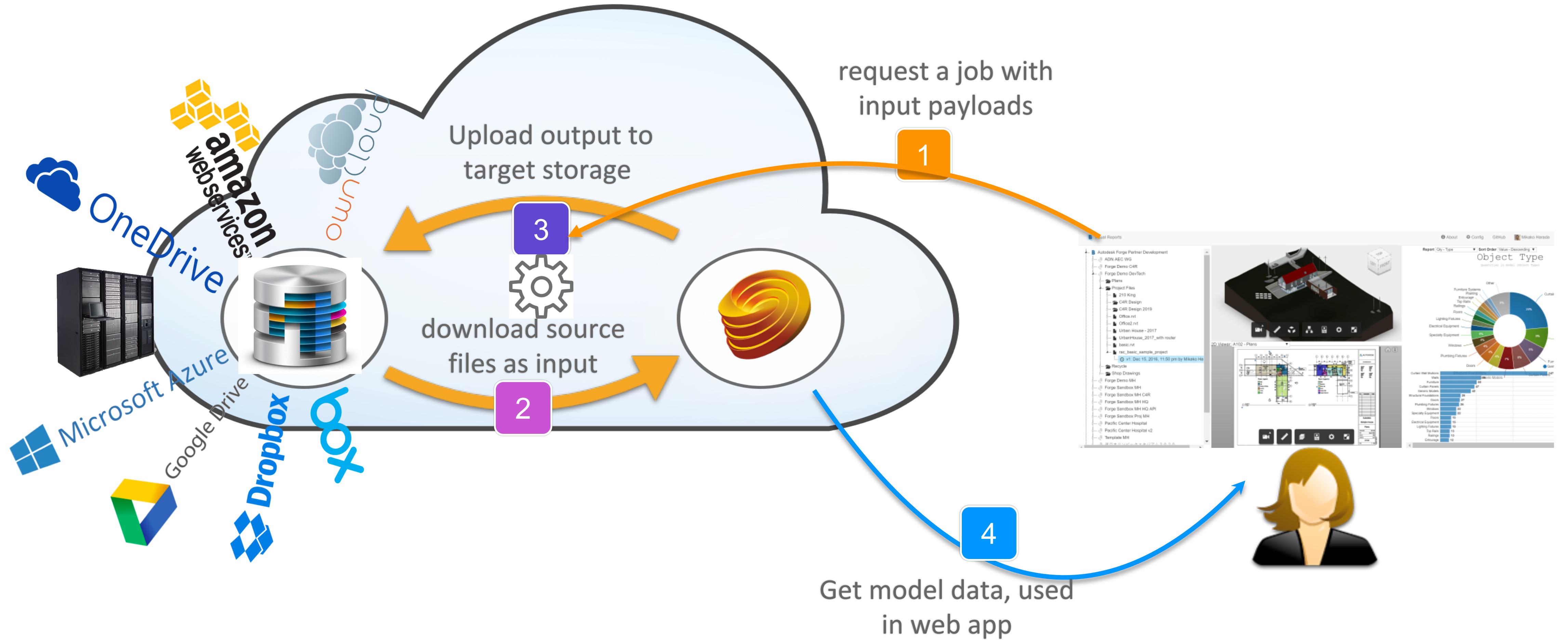
# Design Automation API



# Run Authoring Tools on Cloud

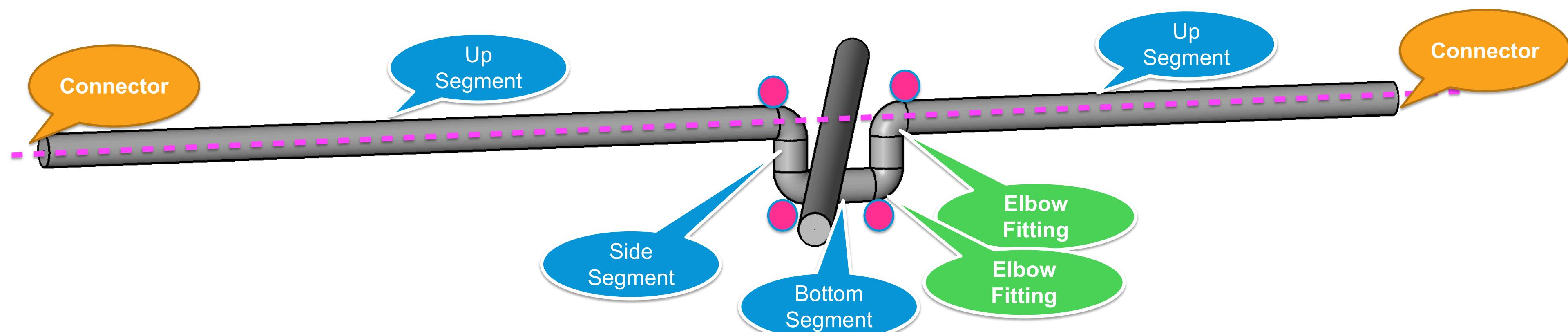
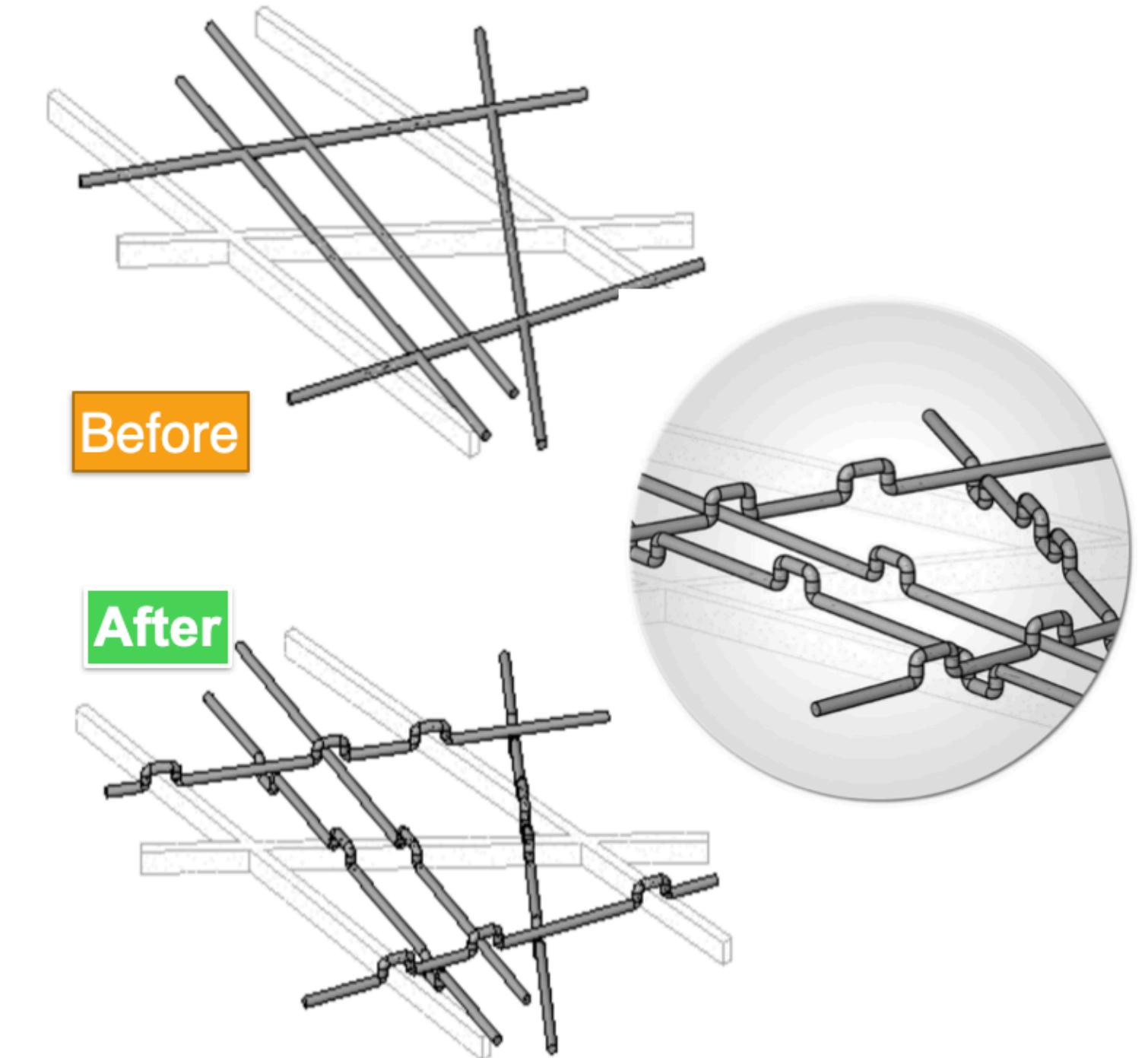


# Workflow of Design Automation



# Avoid Pipe/Duct Obstruction - Revit API

- From one SDK sample
- Detect clashes of Pipes Pipe with Beam, or Pipe with Duct by checking pipe's centerline to detect obstructions.  
Radius of the pipe are not considered
- Keep the Pipe's original direction not change.
- Split the Pipe's line to some segments according to the obstructions detected.
- Re-route the Pipes to avoid the obstructions.



The screenshot shows the Autodesk Forge Revit Family Creation Online interface. On the left, there's a preview of three window styles: Window Double Hung, Window Fixed, and Window Sliding Double. Below these are input fields for Dimensions (Type Name: 500\*200, Height: 5, Width: 2, Inset: 0.05, Sill Height: 3) and Materials (Glass Pane Material: Glass, Sash Material: Maple). A 'Family Name' field contains 'DoubleHungWindow.rfa'. At the bottom are 'Create' and 'Cancel' buttons. To the right is an 'Output Folder' sidebar showing a tree view of BIM360 projects and files, with 'Autodesk Forge Partner Development' selected. Another sidebar on the far right shows a 'Model Viewer' of a room interior with large windows, a bar counter, and a dining table. At the top right, there's a 'Price Book' section with a bar chart titled 'Budget Statistic' comparing quantities for Concrete, Floor, Window, and Door.

## Revit Windows Family Creator

- Provide options of window styles
- Provide family types and parameters
- Generate family file automatically and send to BIM360 folder

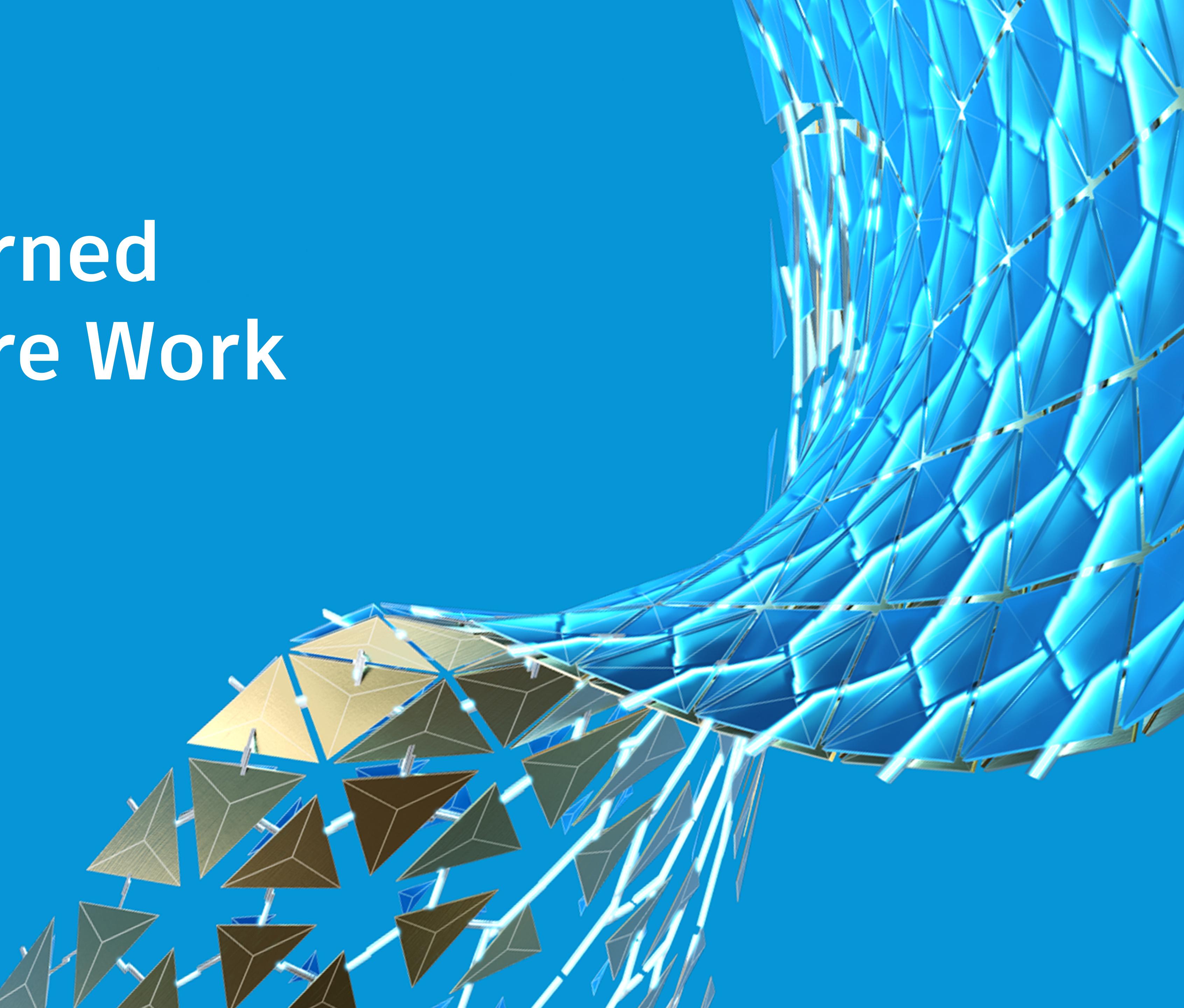
## Extract Quantity for Cost Analysis

- Extract quantities of Revit models
- calculate the budget for each element based on the quantity and price
- import the generated budgets directly into BIM 360 Cost

# Design Automation API

- [Getting Started on Design Automation for Revit on Forge](#)
- [Automation Workflows with the Forge Design Automation API for Revit](#)
- [Design Automation API Tutorials](#)
- [Revit Windows Family Creator](#)
- [Extract Quantity for Cost Analysis](#)
- [Upgrade Revit file Automatically](#)

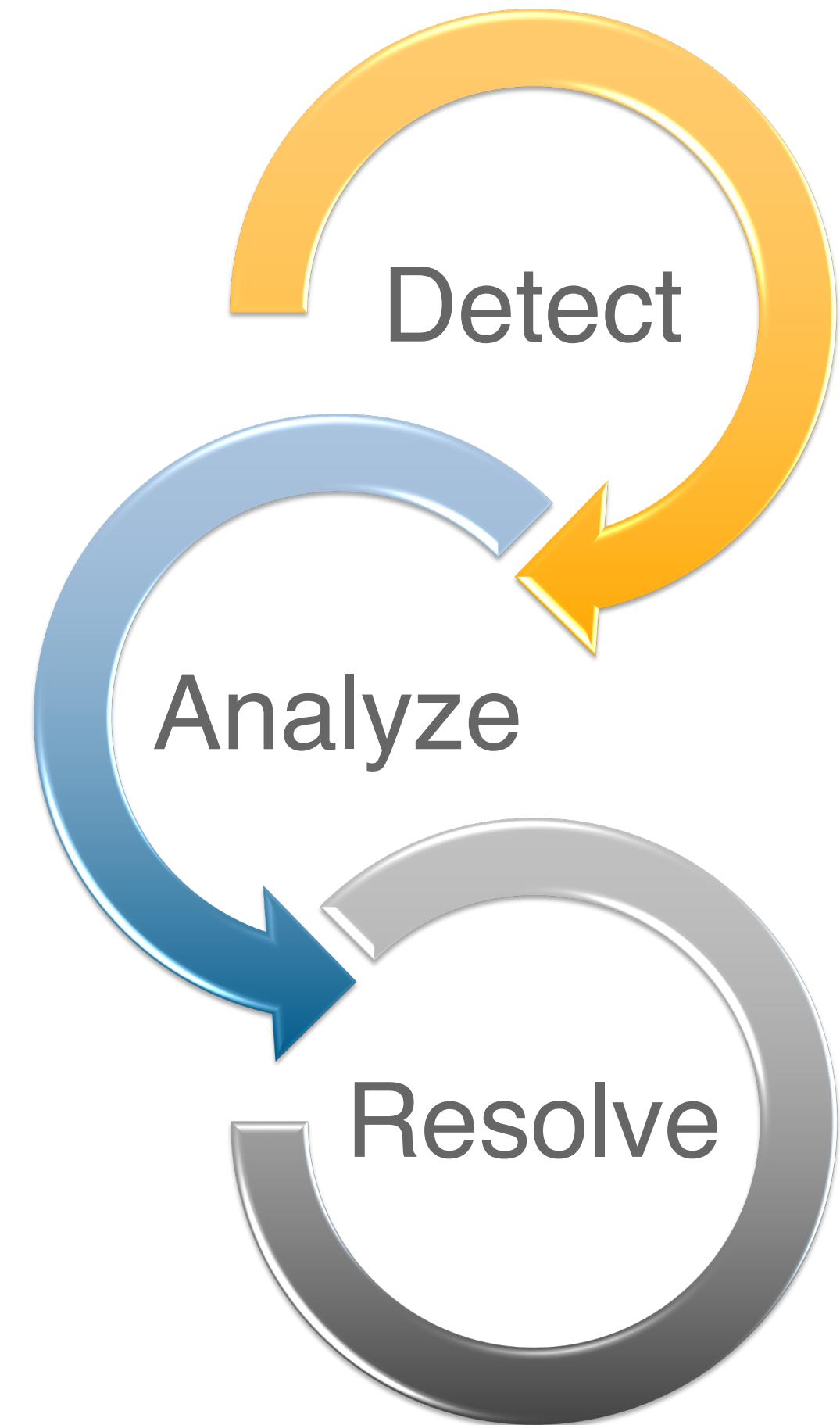
# Lessons Learned & Future Work



# Our Experiment

Goal: Going beyond clash detection

- Demonstrate ideas/possibilities
- Modify a model within the coordination workflow
- Automate some portion of manual process
- Transient modification
- MC API - SQL query on server side



# Limitations

- Model Coordination: RVT, DWG and IFC only
- Design Automation: Revit, AutoCAD, Inventor, 3ds Max  
(vs. Forge Viewer supports more file formats)
- Performance (e.g., webhooks)
- No data about how clashes are solved

# Future Work

## Practical

- Analyze by floors/rooms/spaces /system
- Change family or size
- Batch edit multiple models
- Combinations of multiple resolve options
- Transient editing

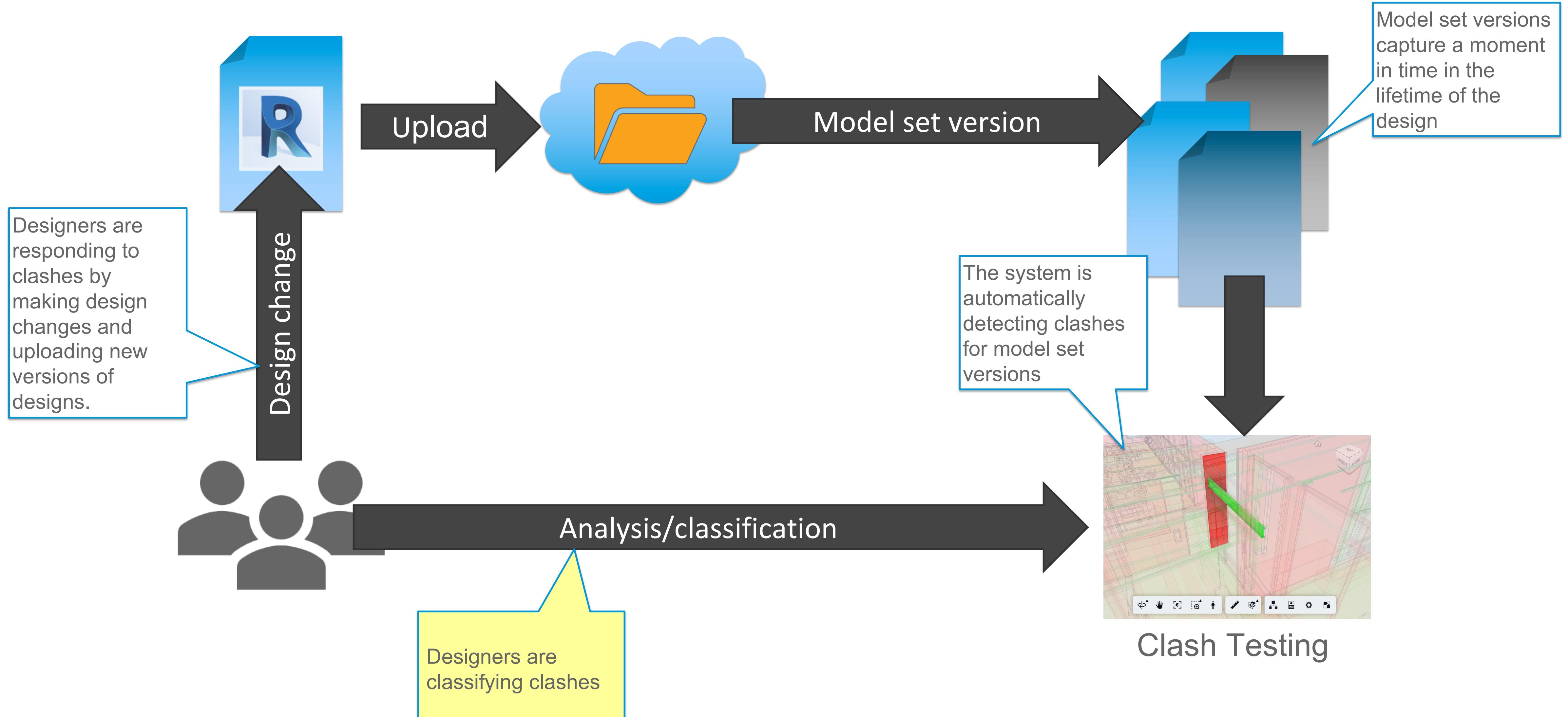
*Something small, something useful*

## Dream project

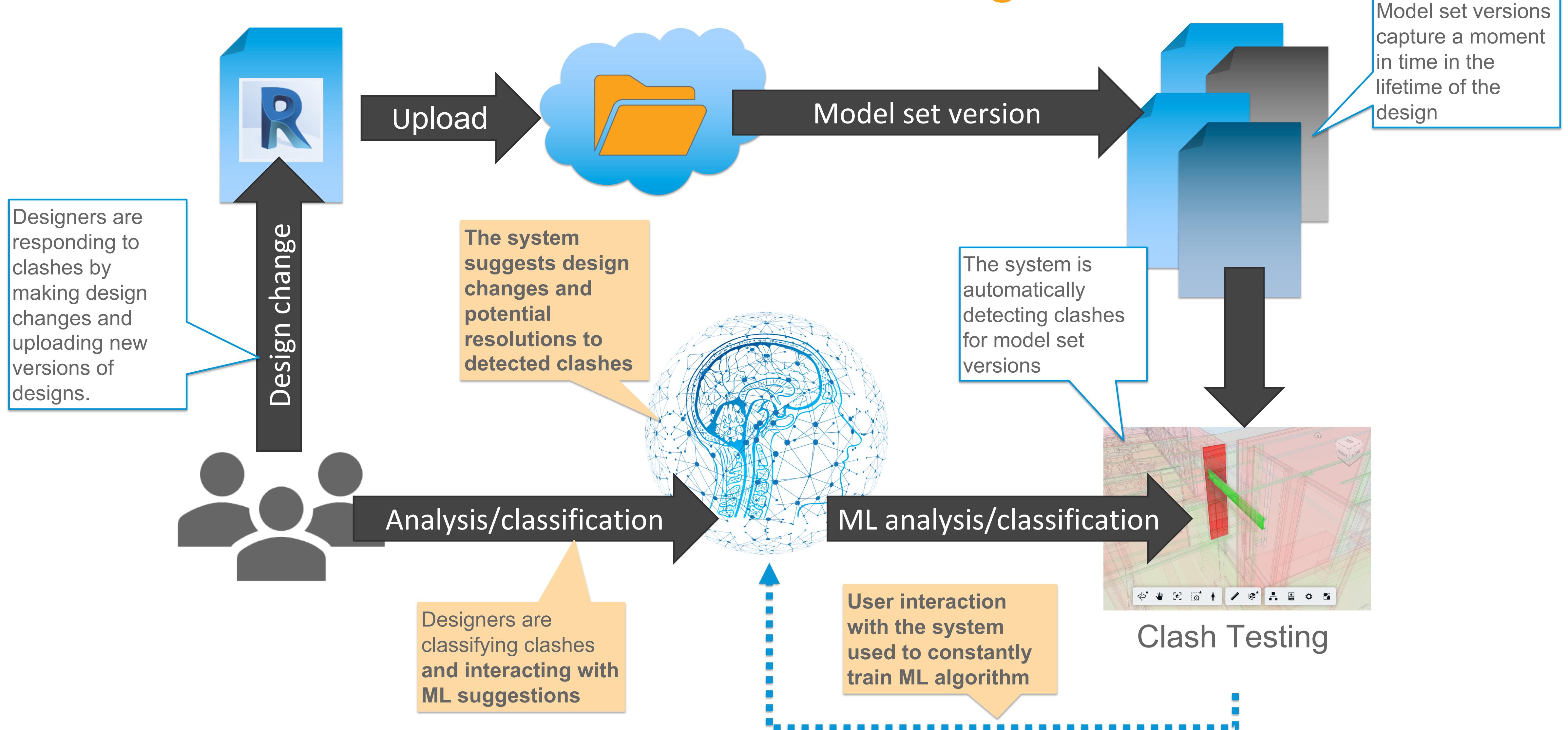
- Suggest potential solution alternatives
- Generative design and optimization
- Machine learning

*We want to learn from you*

# Design Coordination Workflow (Current)



# Design Coordination Workflow w/ Machine Learning



# Summary

- Background and Motivation
- Analyzing Clashes
- Solving Clashes
- Developer Tools Behind
  - Model Coordination API
  - Design Automation API
- Lessons Learned and Future Work

# Questions?

Join us at  
**Class Q&A session (BES468450)**  
**Forge Answer Bar**

# Thank you!



@autodeskforge @coldwood @mikako\_harada



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