AUTODESK. UNIVERSITY

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

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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.

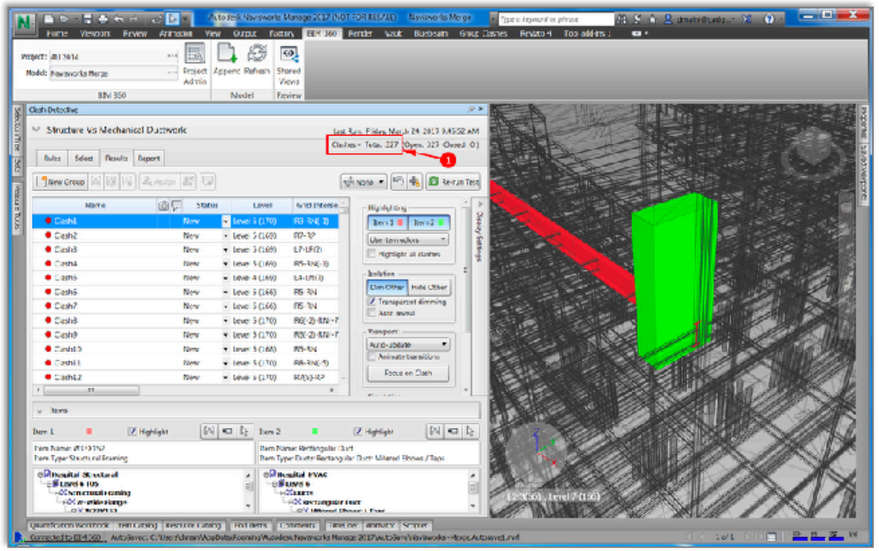
Agenda

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

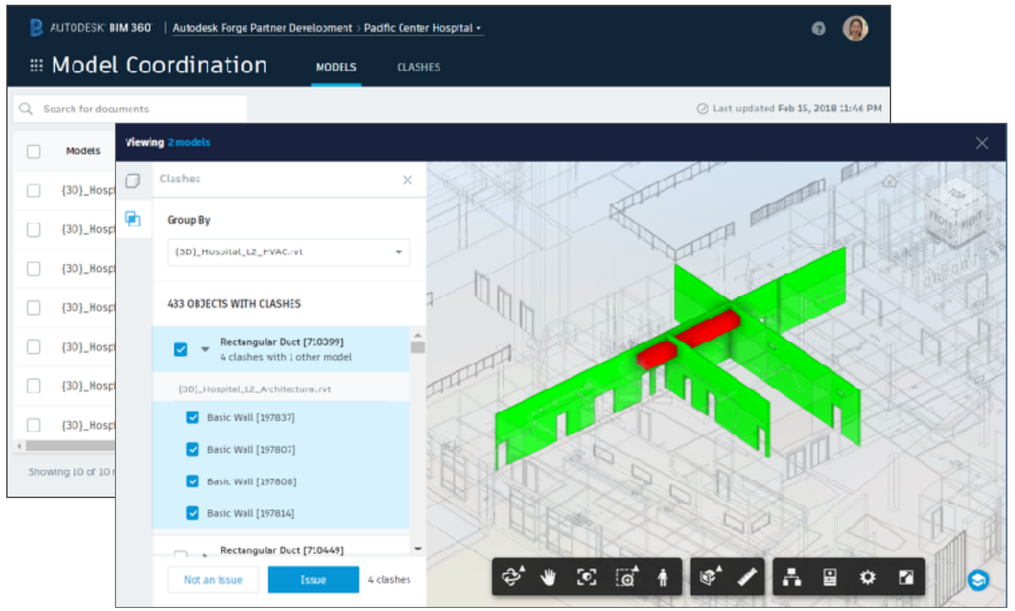
Background and Motivation

Coordination Tools

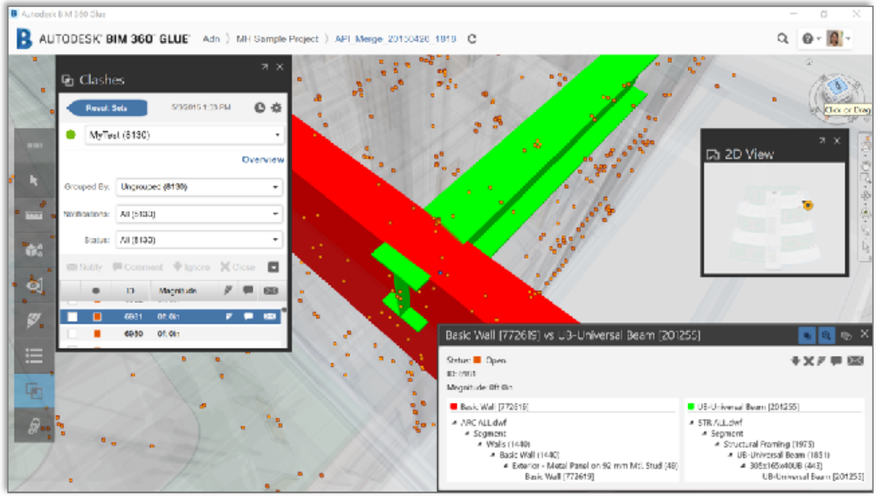
Navisworks



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

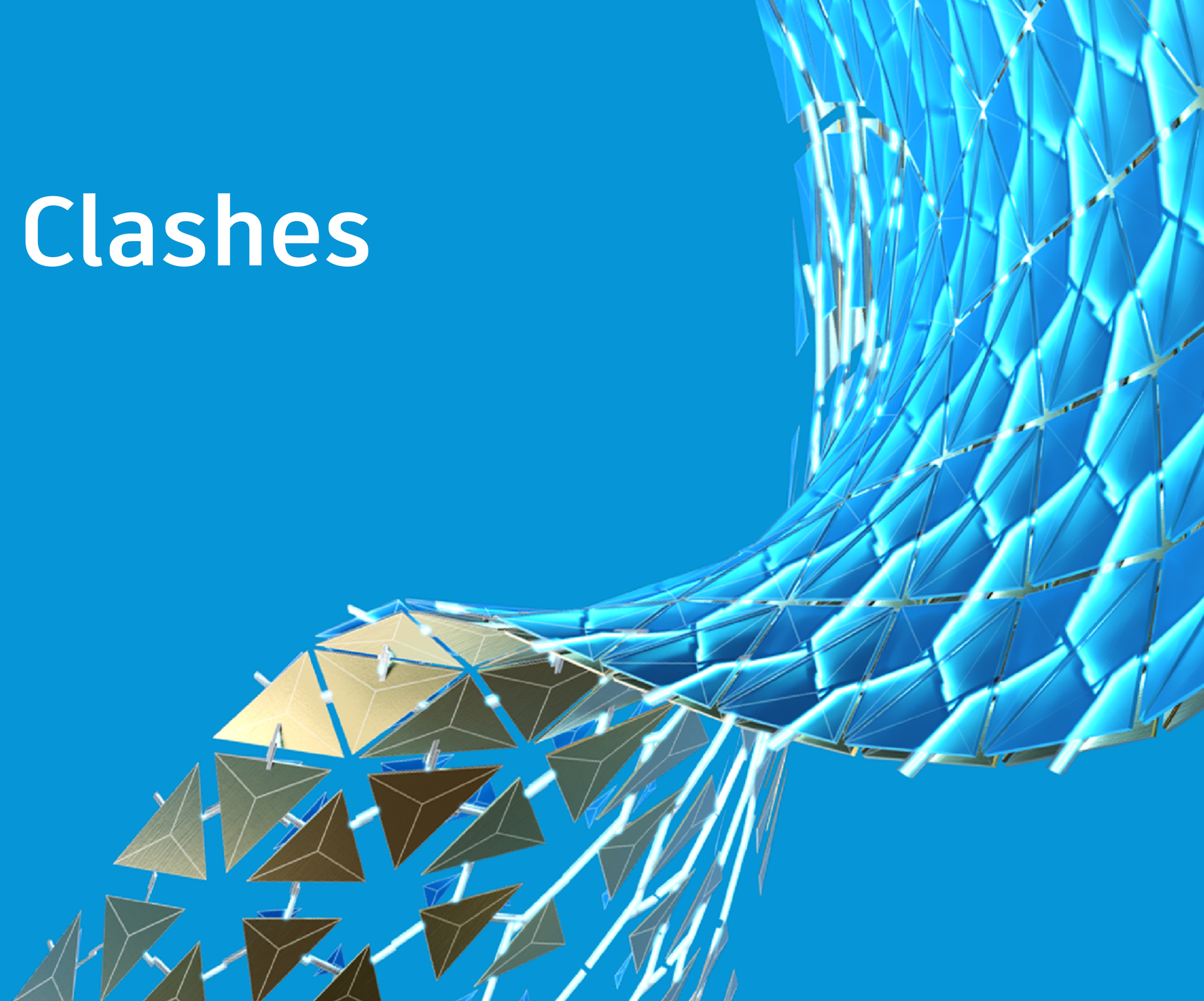
Model Coordination API

Design Automation API

Generative Design

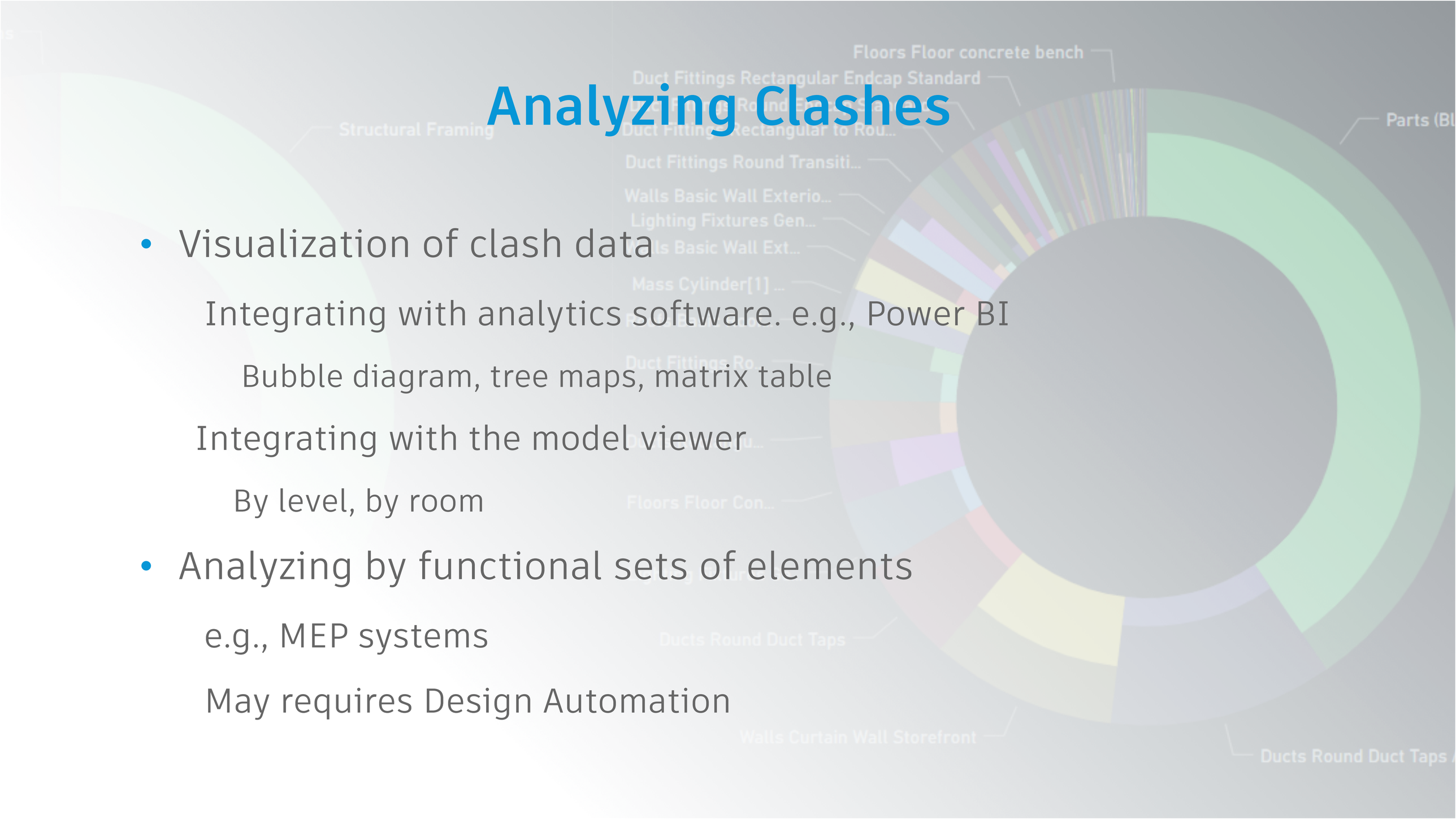
Machine Learning

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

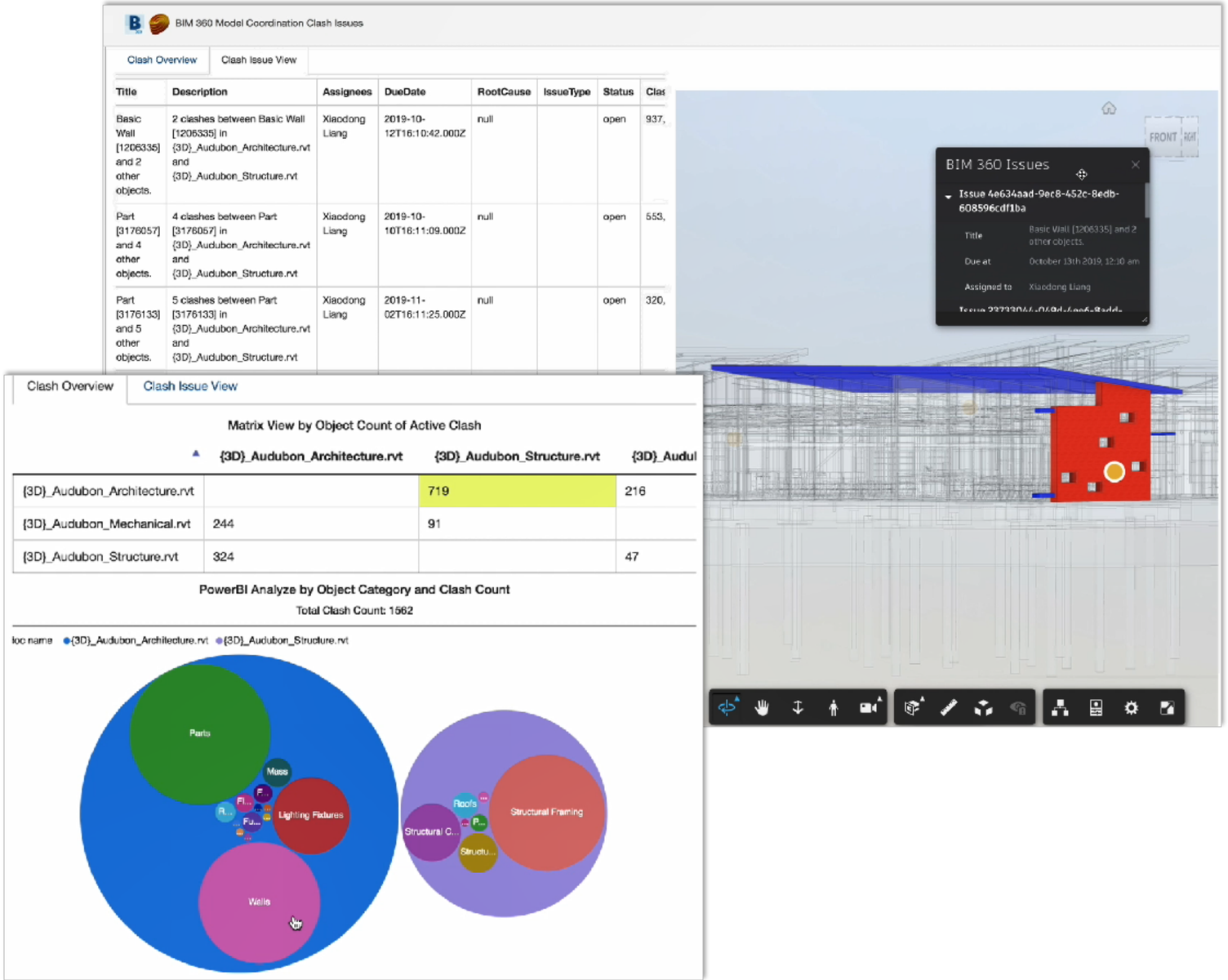


Bubble Diagram, Issues

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

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

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

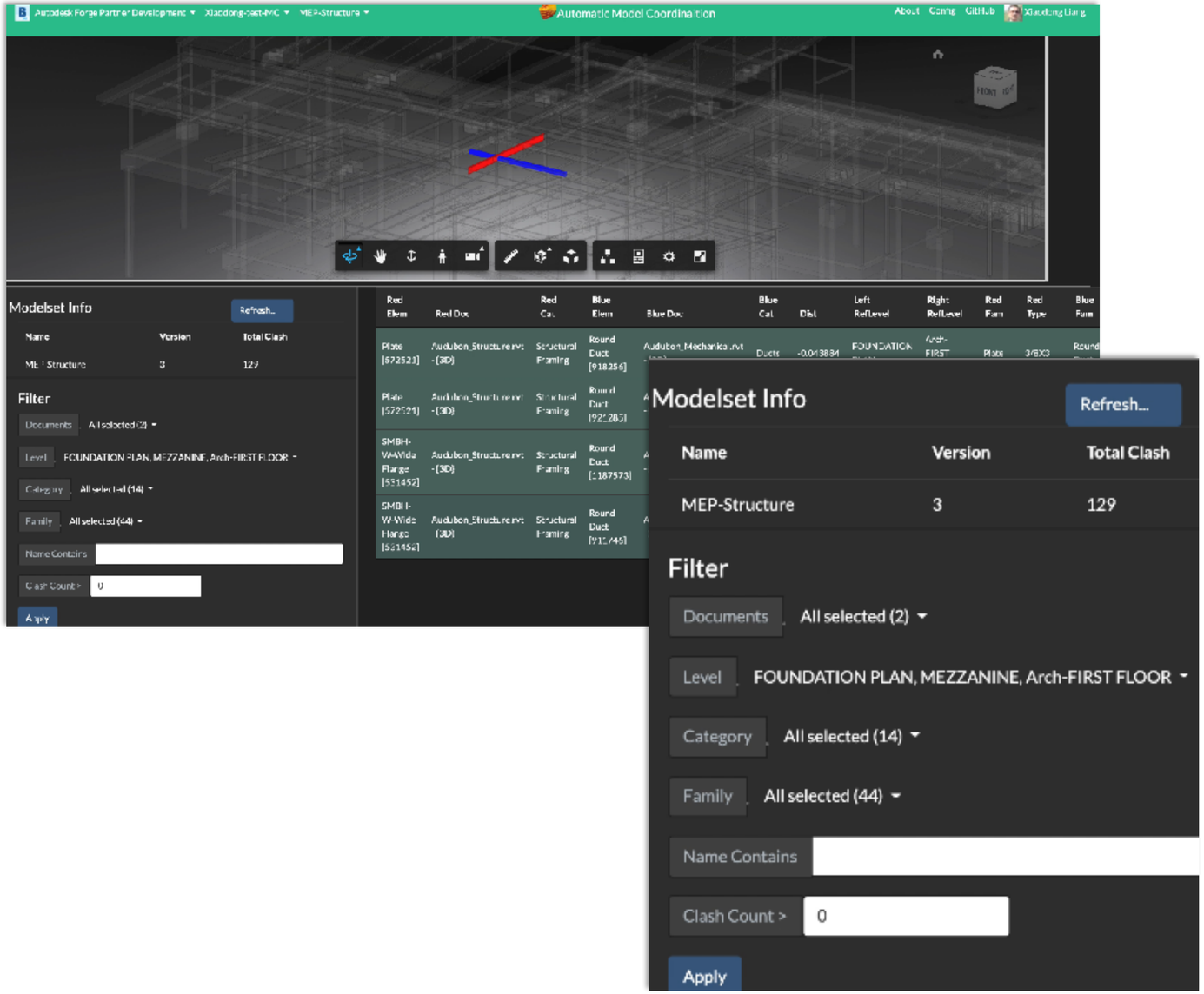
PowerBI Analyze by Object Category and Clash Count

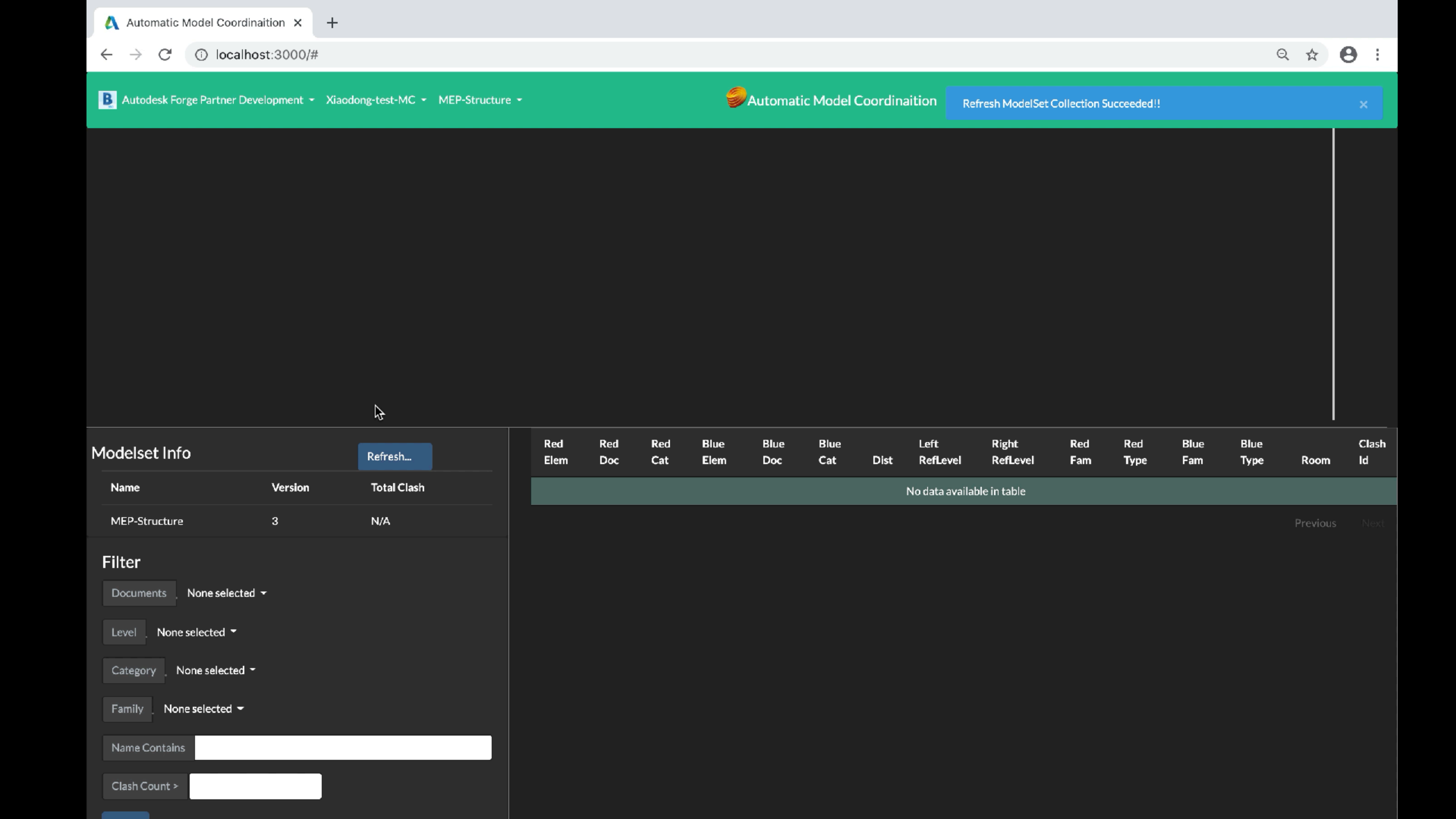
Filtering by Properties

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

Code: [GitHub Sample]

Author: Xiaodong Liang, Autodesk



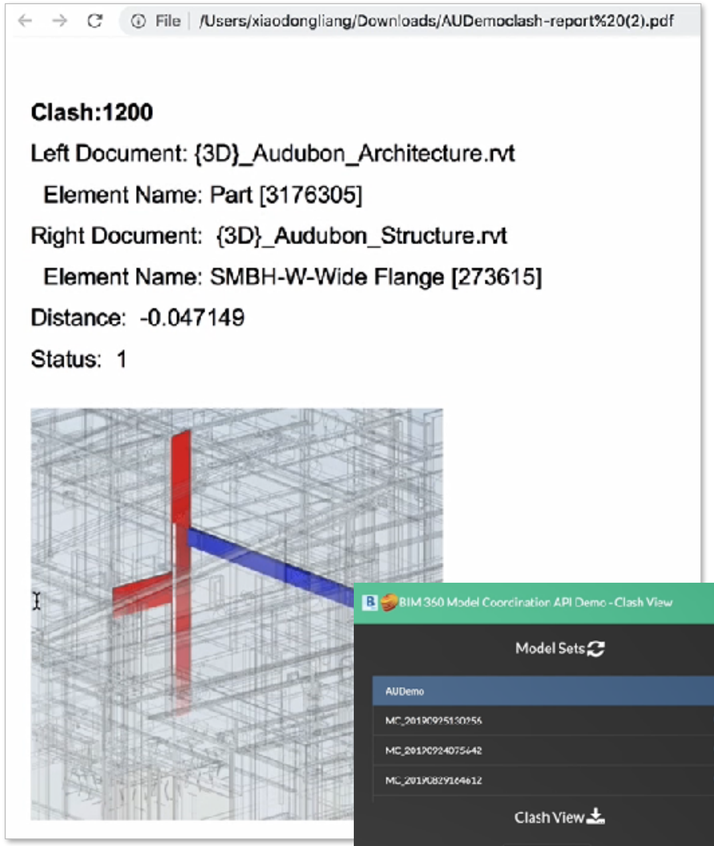

Automatic Model Coordinaition
localhost:3000/#
Autodesk Forge Partner Development
Xiaodong-test-MC
MEP-Structure
Automatic Model Coordinaition
Refresh ModelSet Collection Succeeded!!
Modelset Info
Refresh...
Name
Version
Total Clash
MEP-Structure
3
N/A
Filter
Documents
None selected
Level
None selected
Category
None selected
Family
None selected
Name Contains
Clash Count >
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
Previous
Next

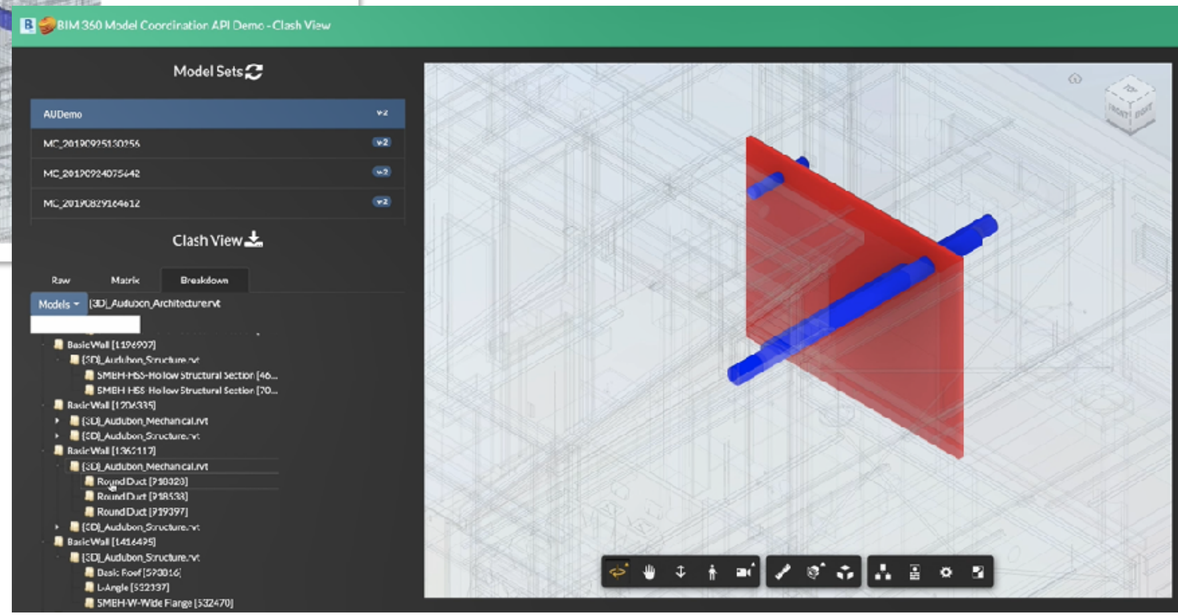
Customized Viewer and Report Generation

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

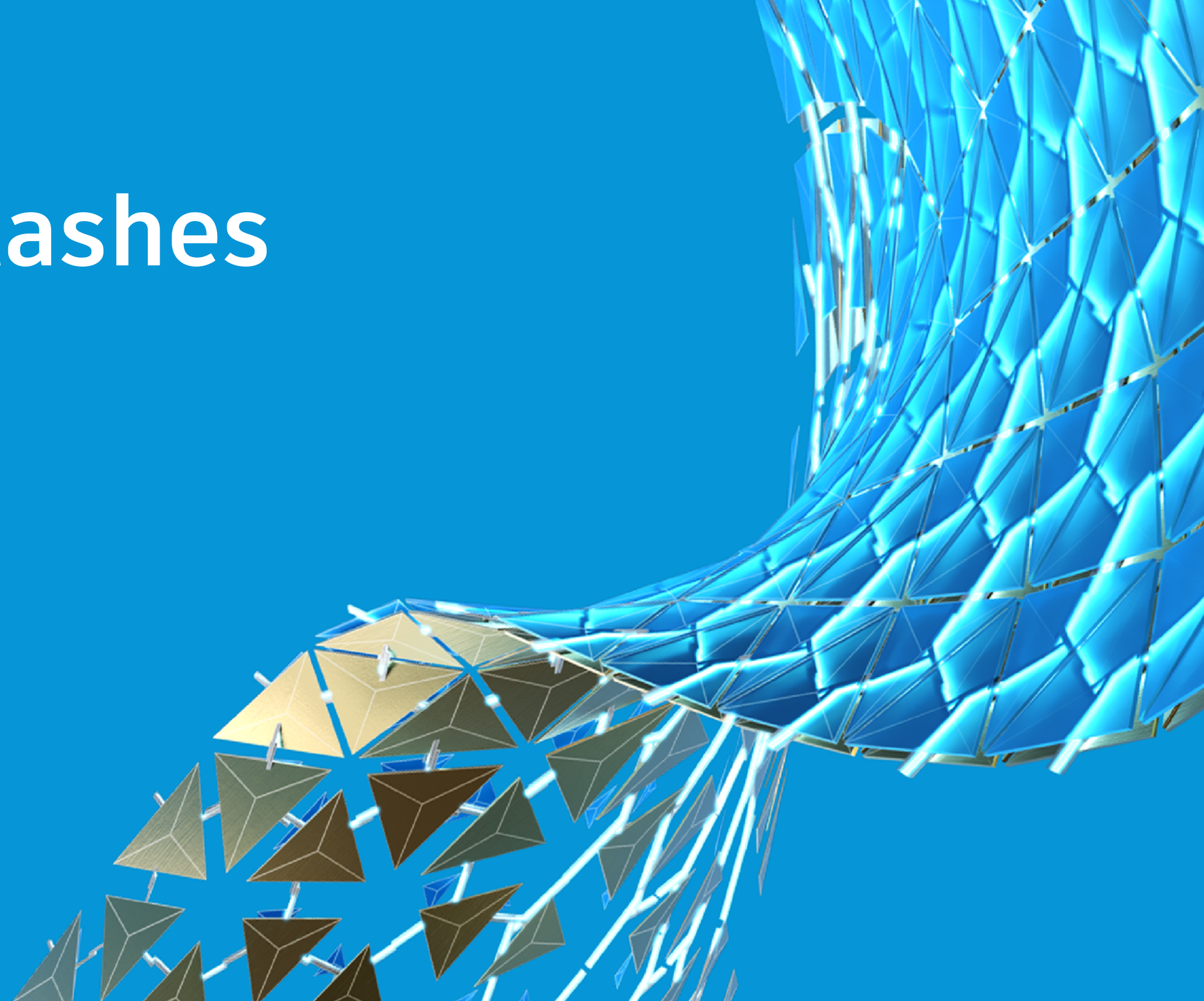
Code: [GitHub Sample]

Author: Xiaodong Liang, Autodesk



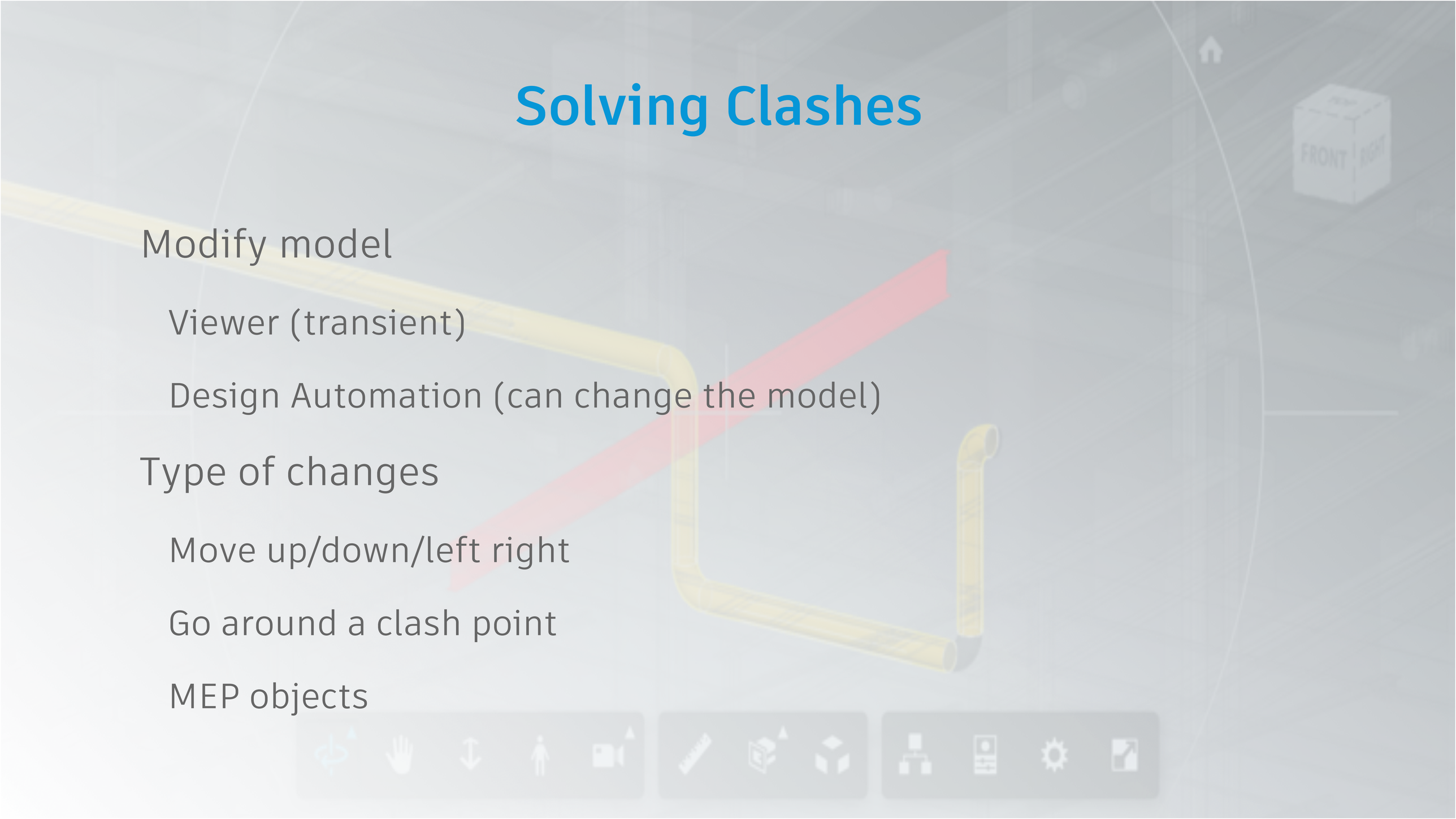


Solving Clashes

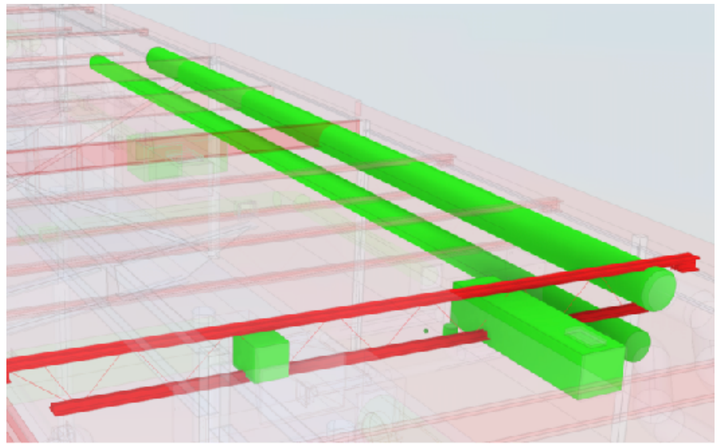


Solving Clashes

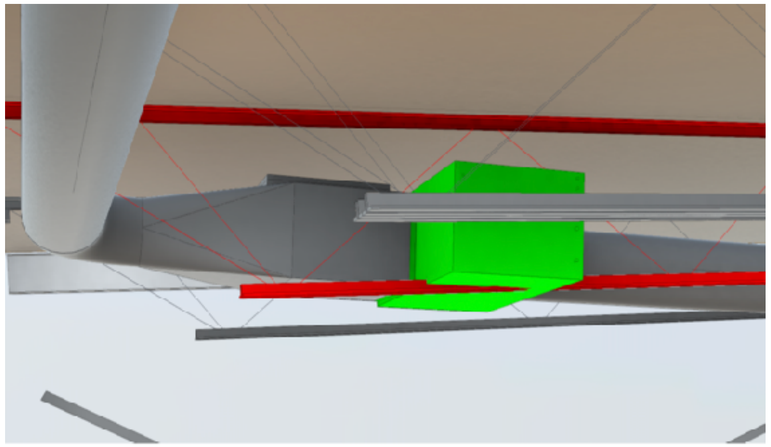
- Modify model
  - Viewer (transient)
  - Design Automation (can change the model)
- Type of changes
  - Move up/down/left right
  - Go around a clash point
  - MEP objects



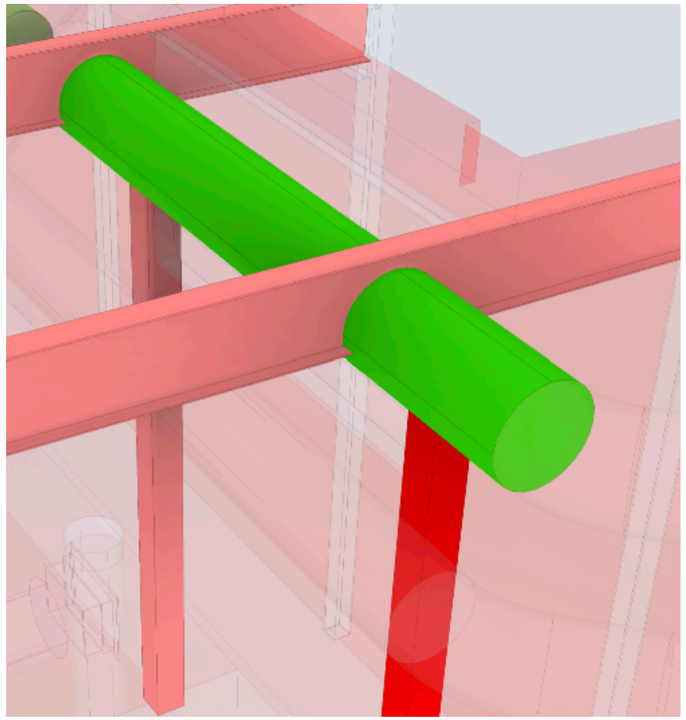
Complex Cases for Automation



Transfer works only a specific direction



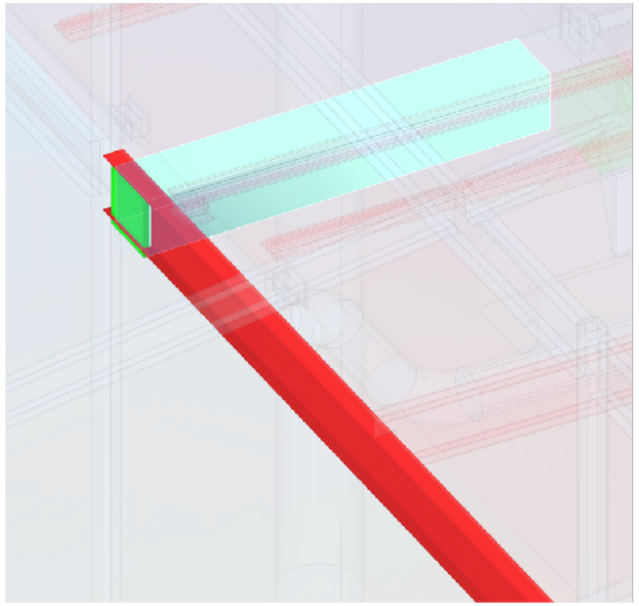
Solving a clash may cause new clash



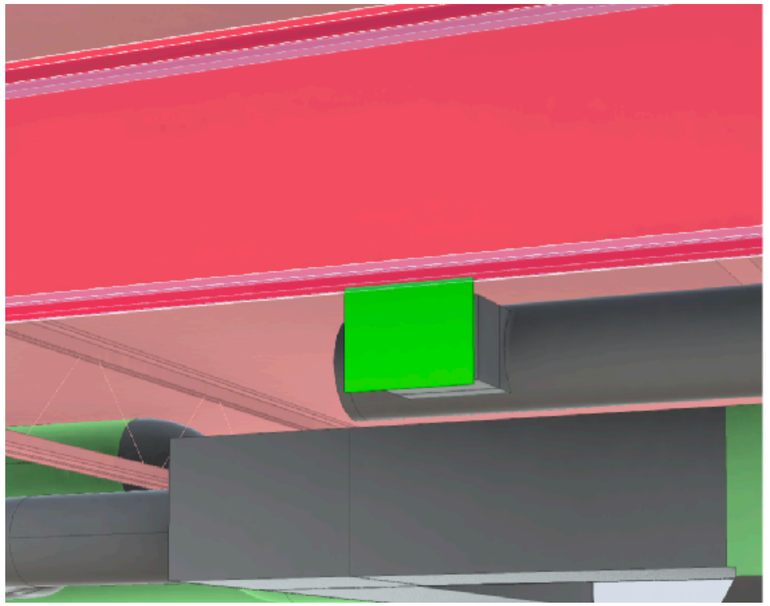
Change of elements will cause connected elements

U-shape is not suitable

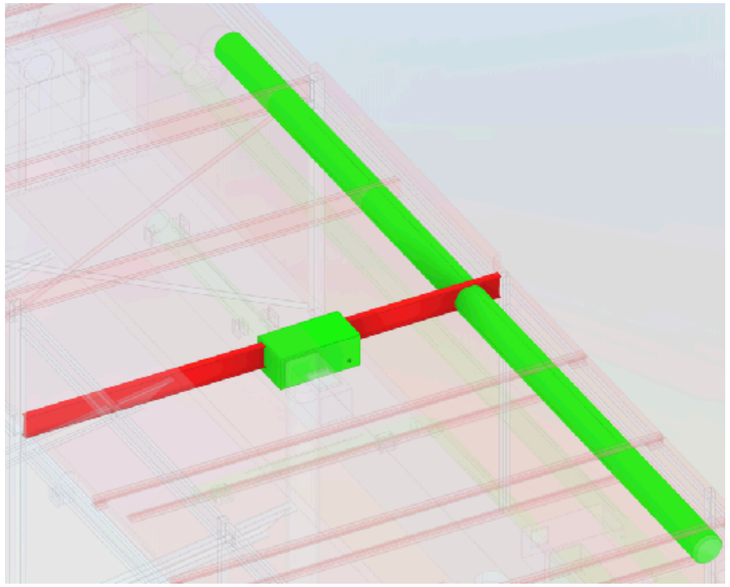
Simple Cases for Automation



Transfer arbitrary direction



Change family type/size

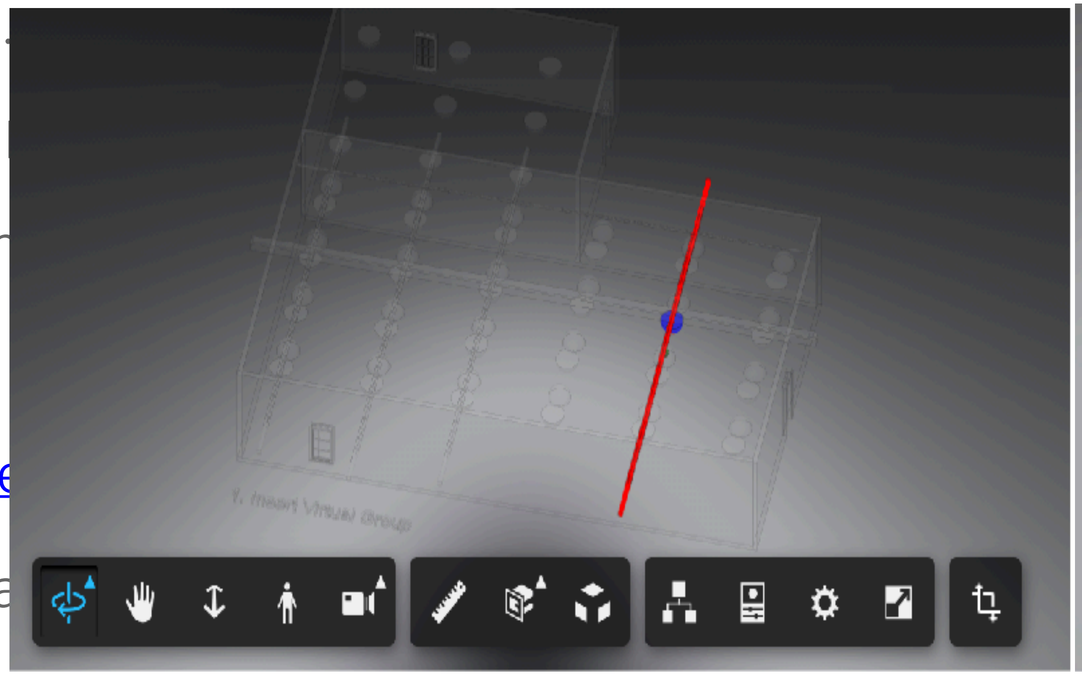


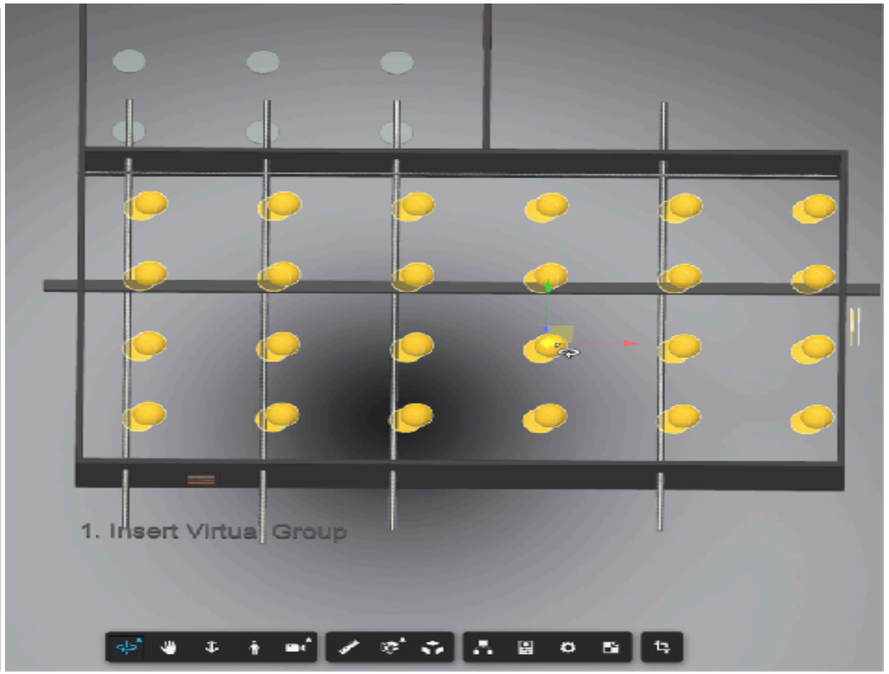
MEP elements (duct/pipe) that can go around (U-shape)

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 I be a preview on th





Code: GitHub Sample

Author: Xiaodong Lia

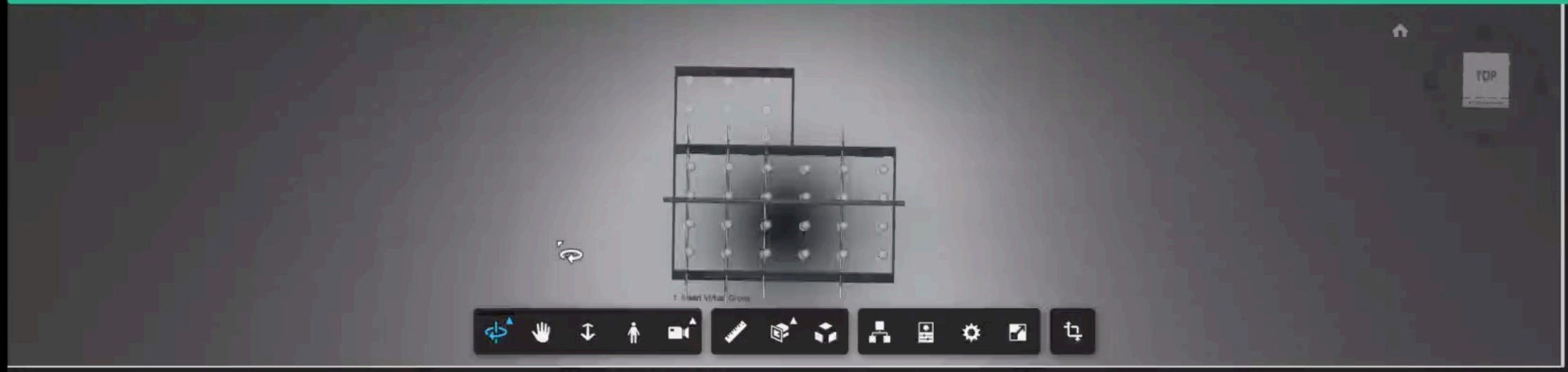
Automatic Reslove Clash

localhost:3000/#

Autodesk Forge Partner Development | Xiaodong-test-MC | Sprinkler

Automatic Reslove Clash

About | Config | GitHub | Xiaodong Liang



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

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

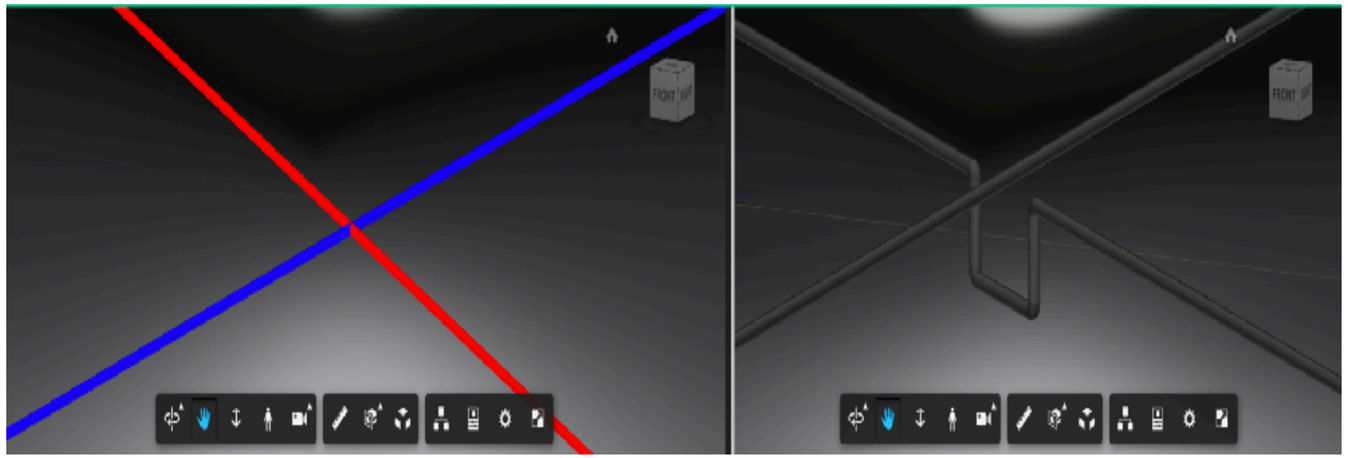
Creating New Clash ModelSet.....

Creating New Clash Version.....

Downloading Clash Data.....

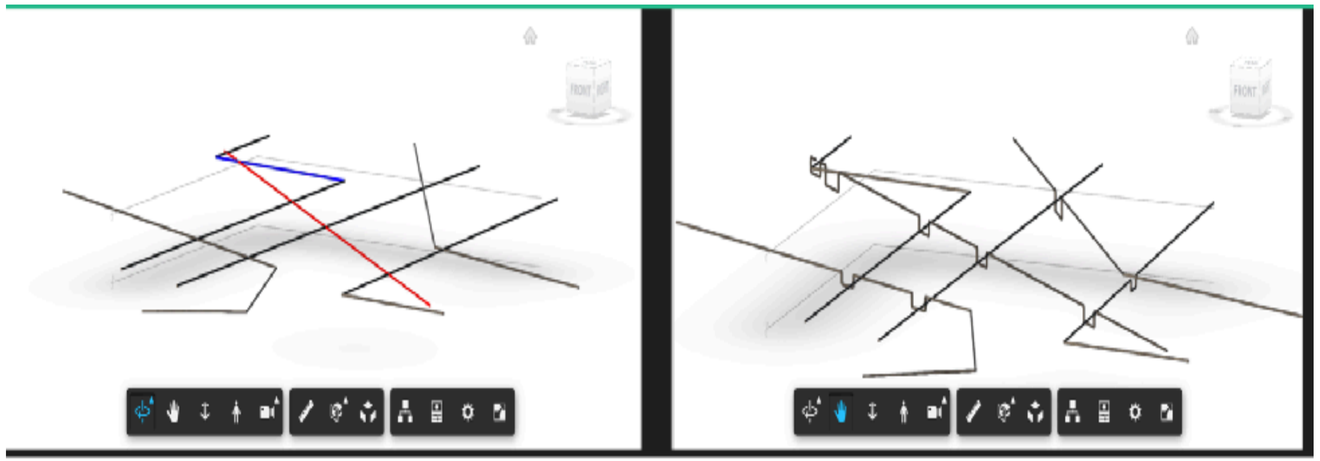
Solve Multiple Pipes Obstruction

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

Refresh... | Reload

Tip Version	Total Clash	Fixed Clash
27		

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												

Previous Next

Coordination

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

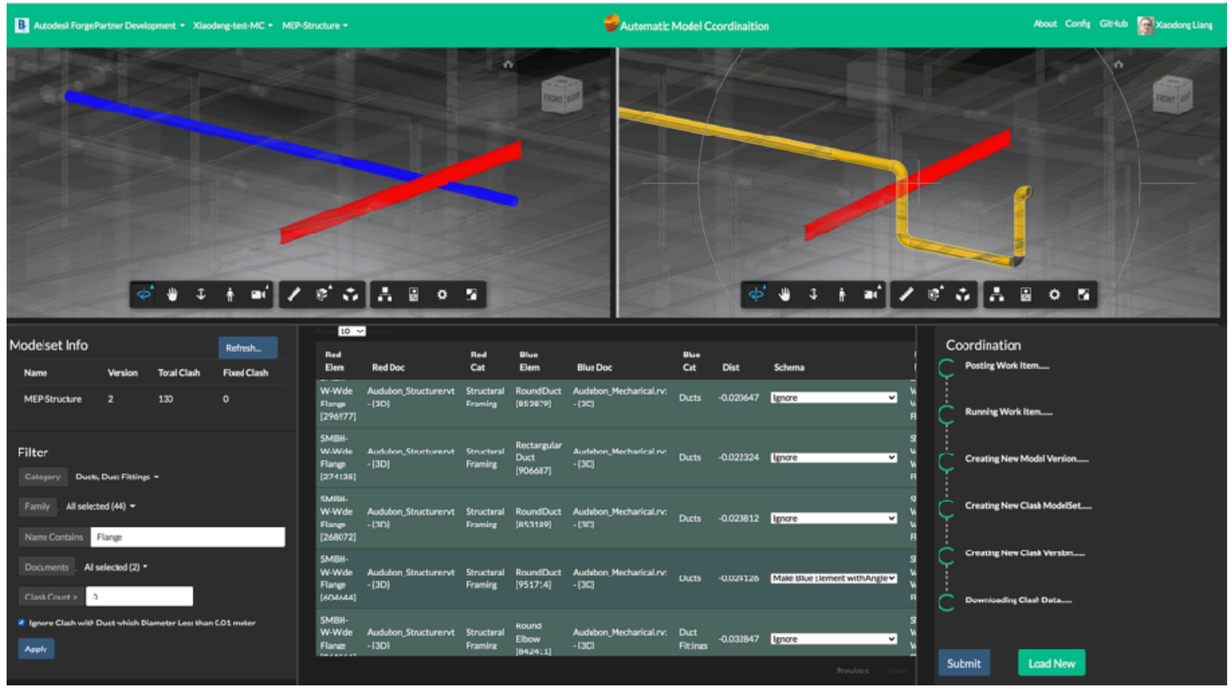
Submit

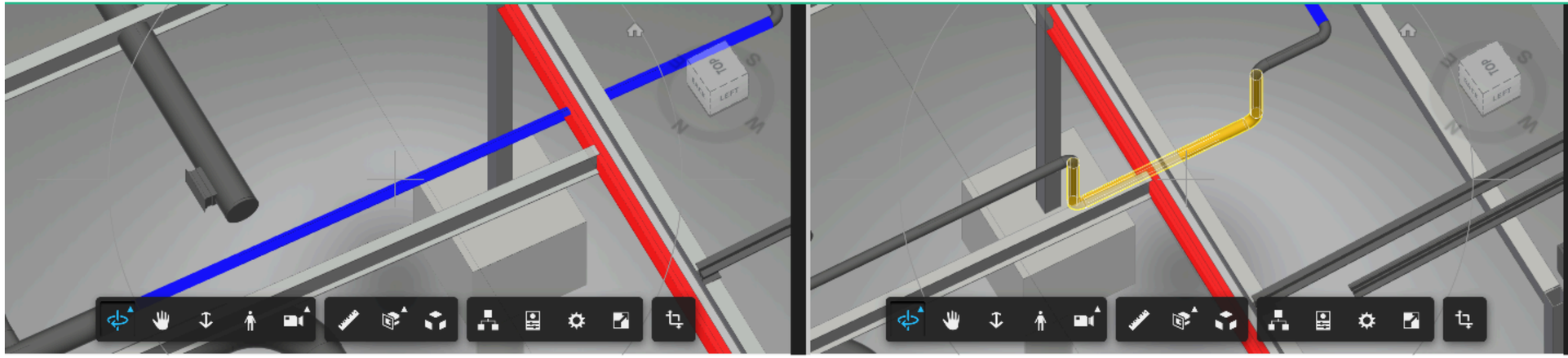
Solve Clashes of Duct with Flange

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

Code: [GitHub Sample]

Author: Xiaodong Liang, Autodesk





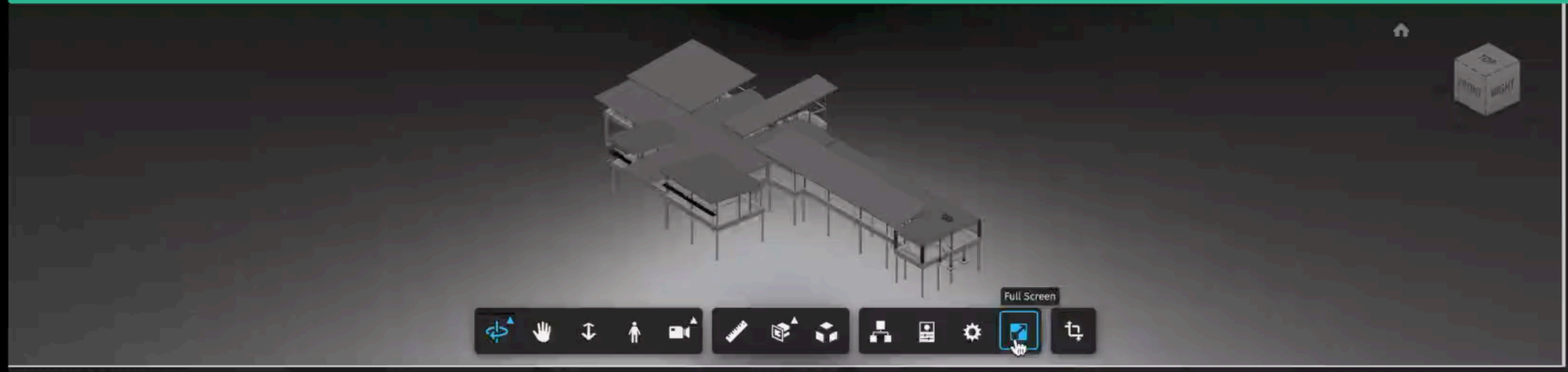
Automatic Reslove Clash

localhost:3000/#

Autodesk Forge Partner Development | Xiaodong-test-MC | MEP-Structure

Automatic Reslove Clash

About | Config | GitHub | Xiaodong Liang



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 Elem	Red Doc	Red Cat	Blue Elem	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

Previous

Coordination

Posting Work Item.....

Running Work Item.....

Creating New Model Version.....

Creating New Clash ModelSet.....

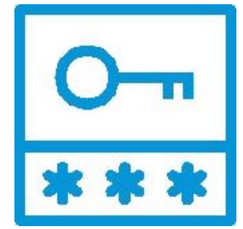
Creating New Clash Version.....

Downloading Clash Data.....

Submit

Developer Tools Behind

Forge



Authentication

Data Management

Design Automation

BIM 360

Reality Capture

Model Derivatives

Viewer

Webhooks

Forge

Authentication

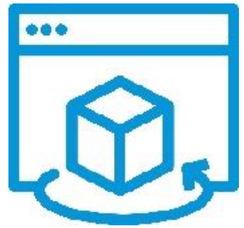
Data Management

Design Automation

BIM 360

Reality Capture

Model Derivatives



Viewer

Webhooks

Integration with PowerBI

1

Get Clash Results


```
{
    "scope": "07a267aa-0e6e-456e-b674-d3c9796dc1a9",
    "version": 2,
    "clashes": [{
            "id": 1,
            "clash": [
                482,
                148
            ],
            "dist": -0.19088,
            "status": 1
        },
        {
            "id": 2,
            "clash": [
```


2

Generate Matrix View

Matrix View by Object Count of Active Clash

	{3D}_Audubon_Structure.rvt	{3D}_Audubon_Architecture.rvt	{3D}_Audubo
{3D}_Audubon_Architecture.rvt	723		216
{3D}_Audubon_Mechanical.rvt	89	244	
{3D}_Audubon_Structure.rvt		327	45

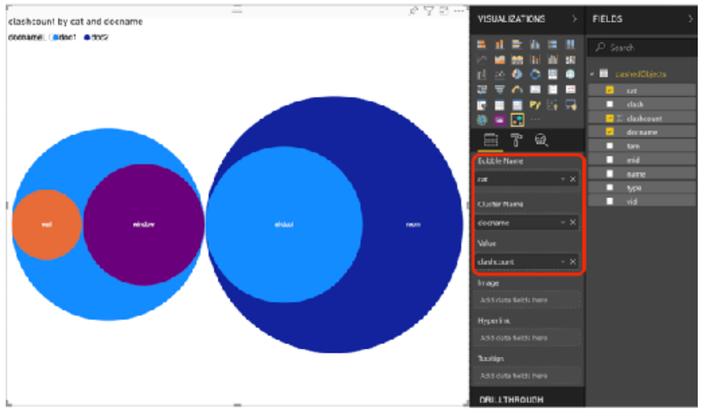
3

Get Elements Properties


```
0
  file : "76137261"
  db : "a274659"
  docs
  id : 2398
  name : "HSS-Hollow Structural Section-Column [259914]"
  category : "Structural Columns"
  family : "HSS-Hollow Structural Section-Column"
  type : "HSS6X6X.1875"
1
  file : "7960883e"
  db : "b834bb65"
  docs
  id : 4076
  name : "Rectangular Mullion [1040998]"
  category : "Walls"
  family : "Curtain Wall"
  type : "Storefront"
```

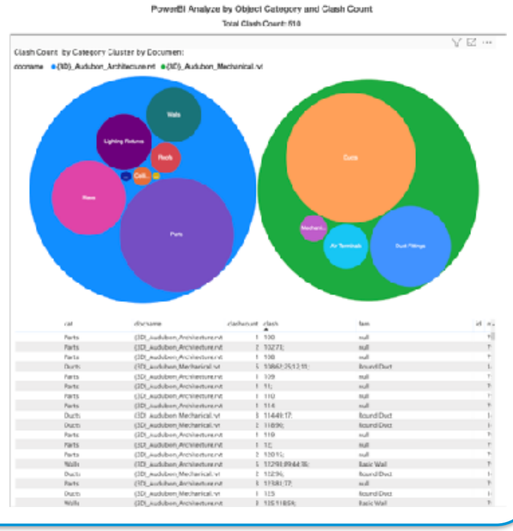

4

Push Property Data to Power BI Report Template



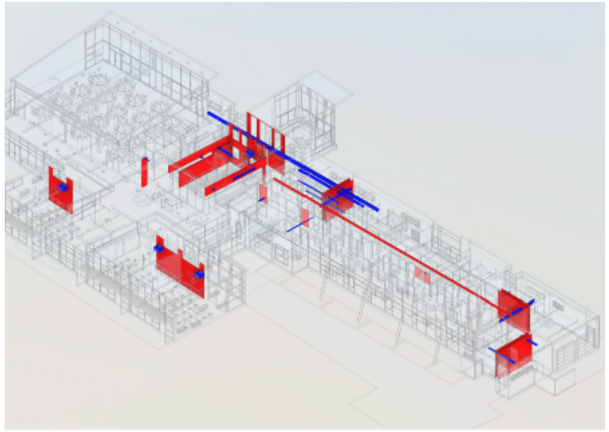
5

Render Report in Web App



2

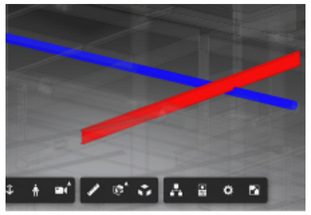
Load a Pair of Documents to Forge Viewer



Integration with Design Automation for Revit

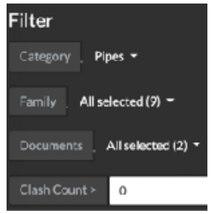
1

Get Clash Results by Model Coordination



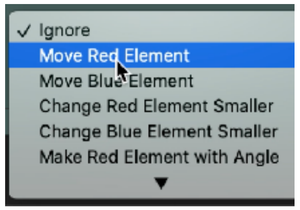
2

Analyze by Filtering Specific Properties



3

Option Decision:
Move/Change Family/Make Angle



4

Send to Design Automation

5

Create New Model Version in BIM 360

6

Trigger New Clash Test

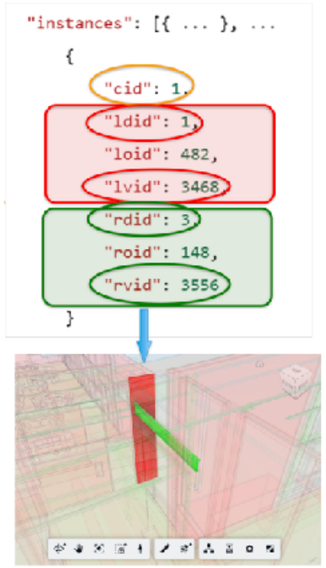
Model
Coordination

Model Coordination API

Model Coordination API

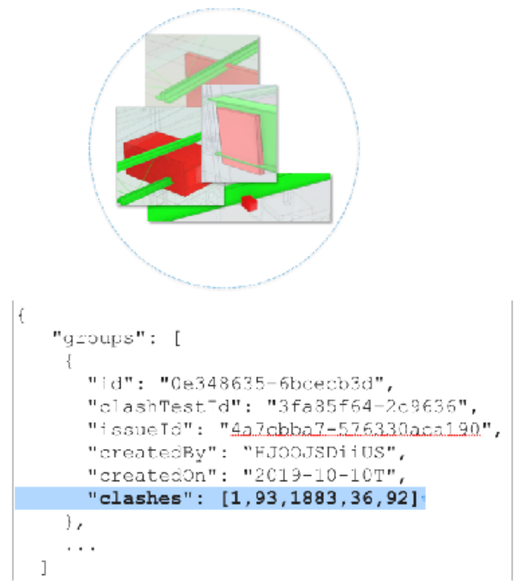
Model set versions through time

Clash tests for every model set version



BIM index properties for every model set version

Closed and Assigned (Issue) Clash Groups



Clash

Clash

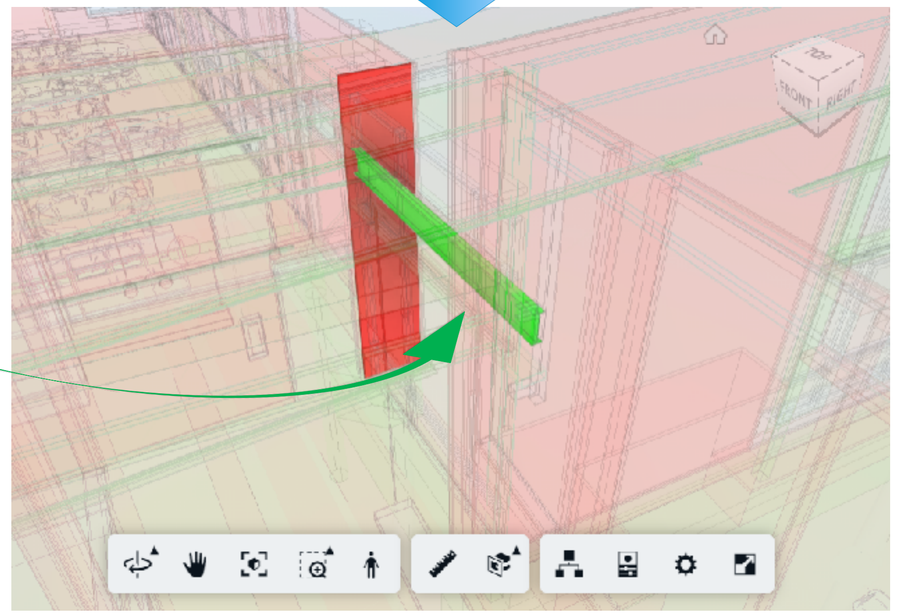
```
"clashes": [{
        "id": 1,
        "clash": [
            482,
            148
        ],
        "dist": -0.19088,
        "status": 1
    },
```

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.LX4O5vtjSne2MkGwjLIwQA?version=1"
    },
    {
        "id": 2,
        "urn": "urn:adsk.wipprod:fs.file:vf.oOwETj03RmSyaP1fhcW9bQ?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 Valus


```
{
    "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

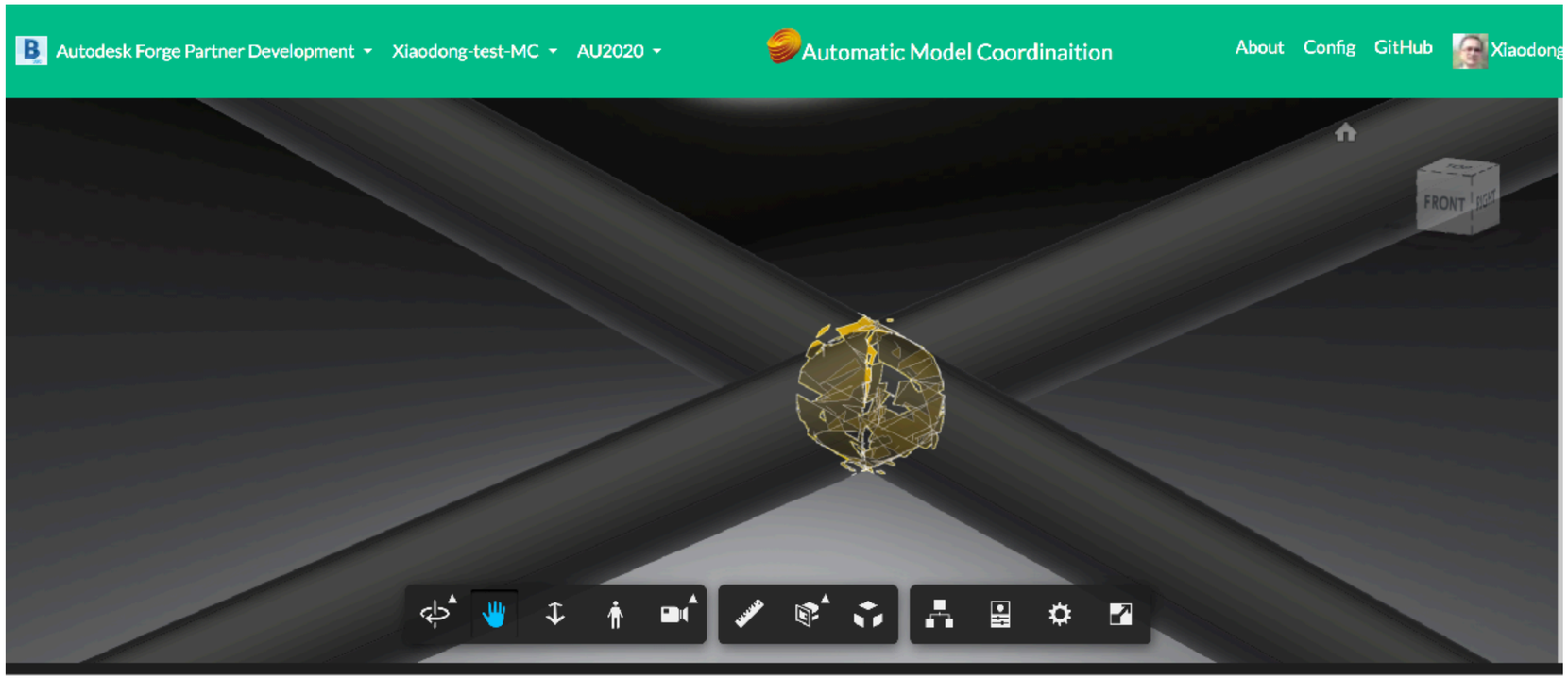
Available

- Clash center
- Clash range(box)
- Shortest direction to resolve clash
- Webhook

Unavailable

Calculation of Clash Center and Range

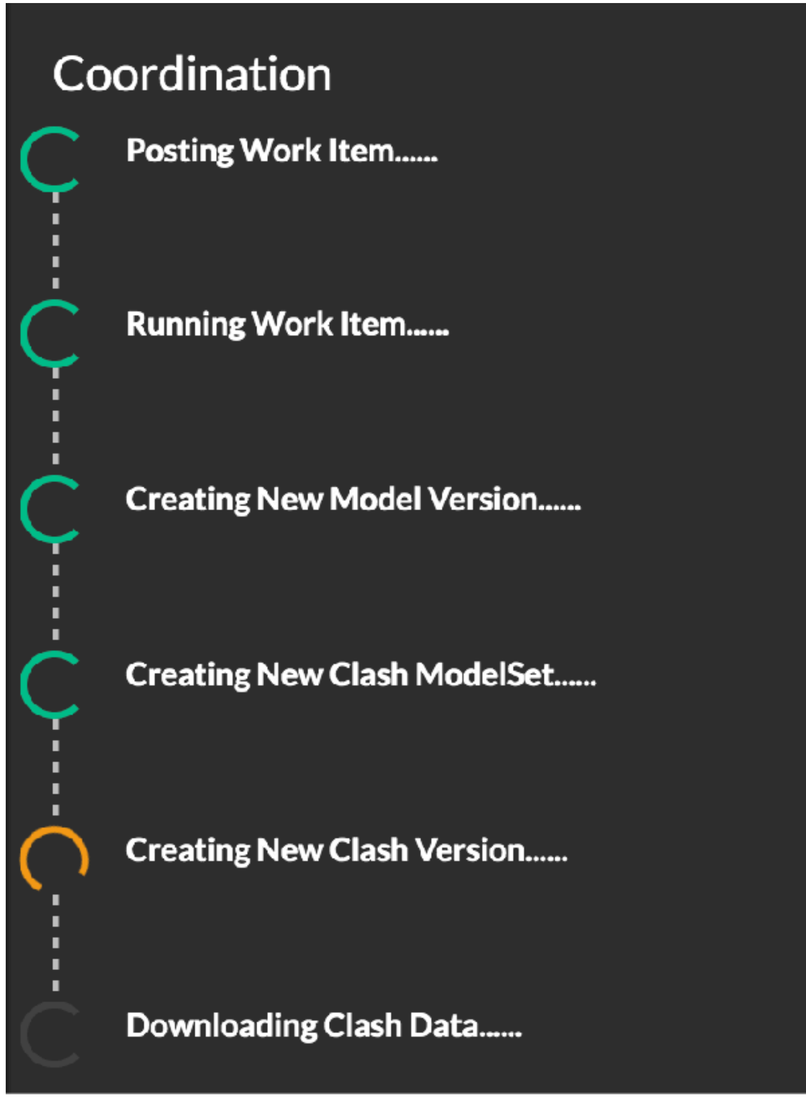
- With mesh data of Forge Viewer API (fragments vertices)
- Intersection of elements mesh (by THREE.js CSG)
- Balance between precise and performance (CSG tolerance)



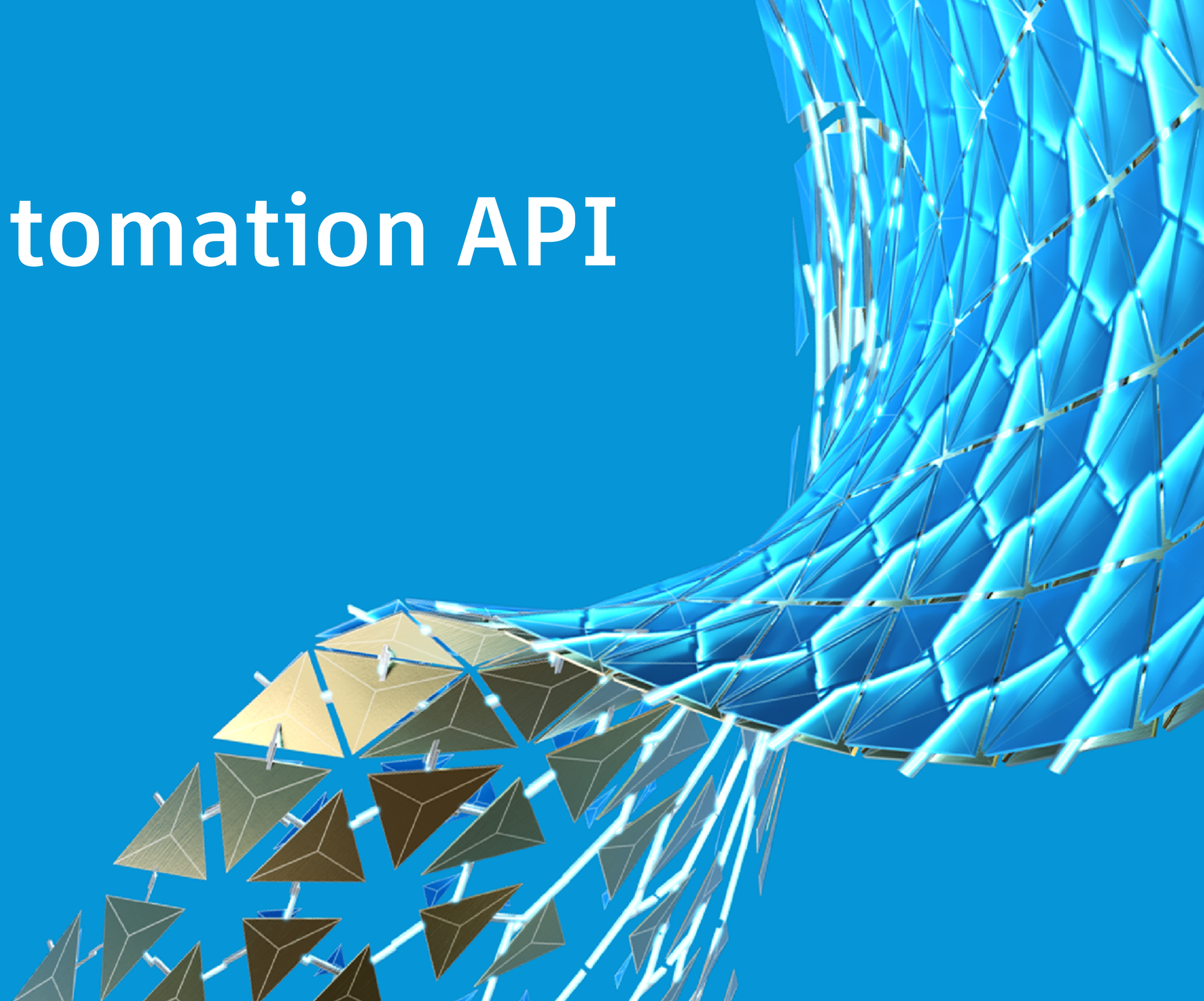
Process Time

Majority is time of notifications

- **A little time**: prepare parameters, create storage for new version file, post item
- **Reasonble time**: running workitem, depending on internet connection between Forge and source/target storage, and volume of elements to update.
- **Quick time**: create new version file in BIM360 folder
- **Longer time:** depending on when version:update of folder notifies model-set to run new coordination.
- **Longer time:** depending on when model coordination notifies a clash test is done.
- **Reasonble time**, download clash raw data and index properties, depending on data volume.



Design Automation API



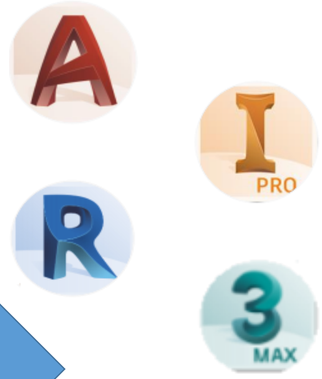
Run Authoring Tools on Cloud

Input

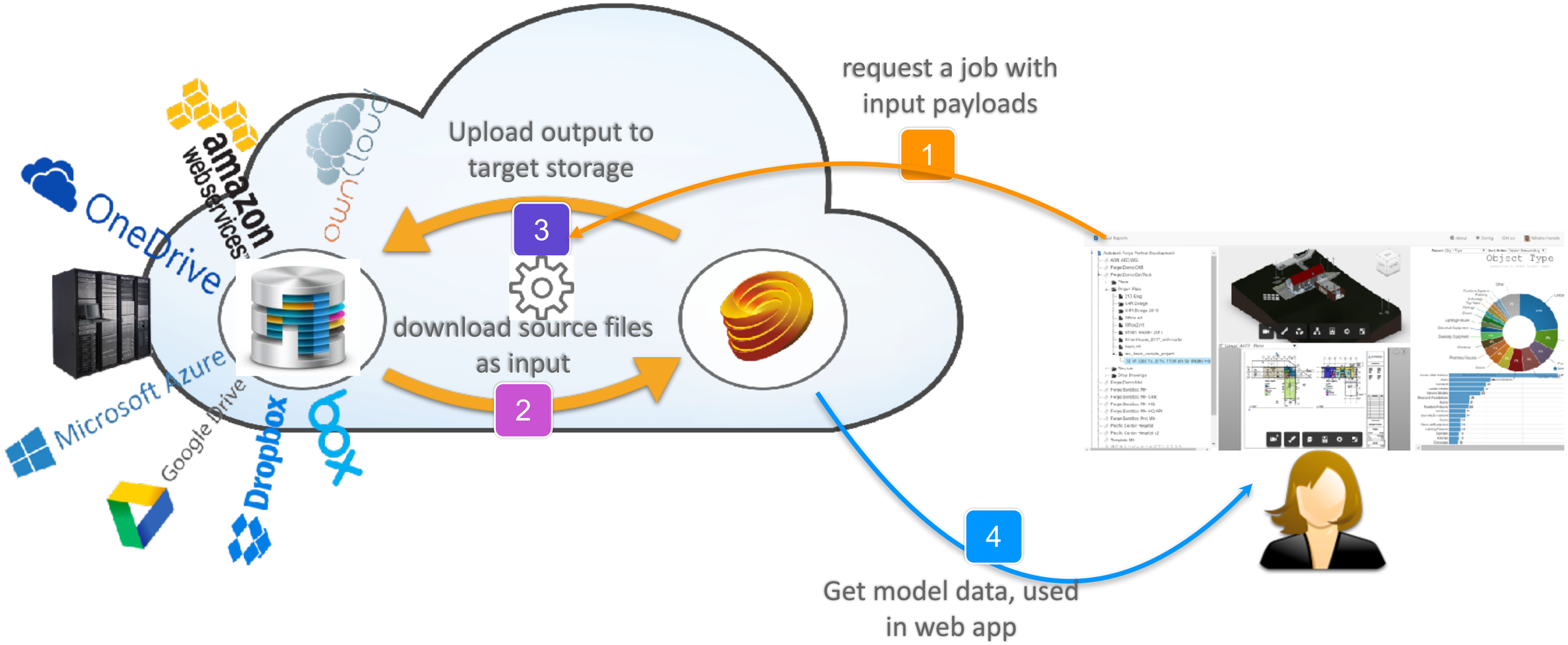
- Original files
- Parameter Data

Output

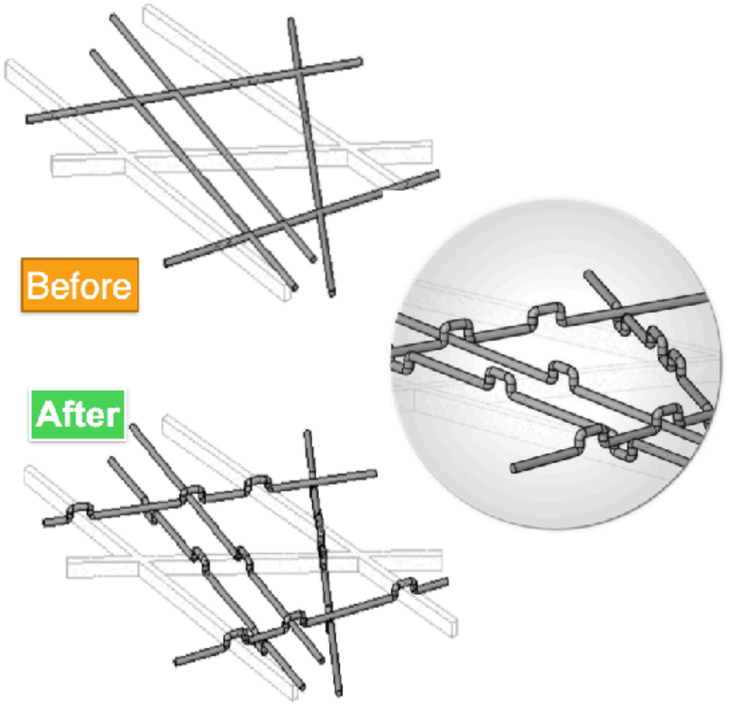
- New File
- Modified File
- Extracted Data
- Exported File
- Zip



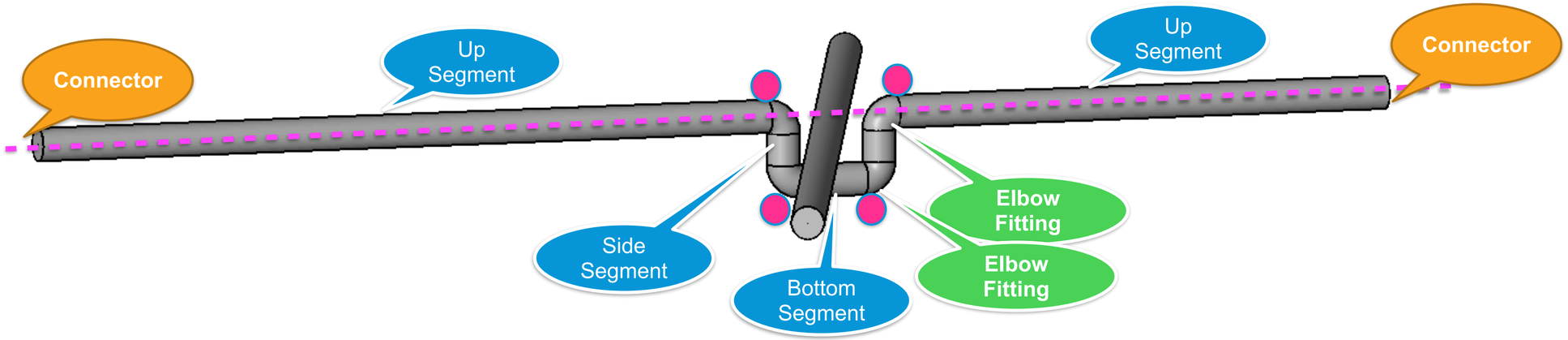
Workflow of Design Automation

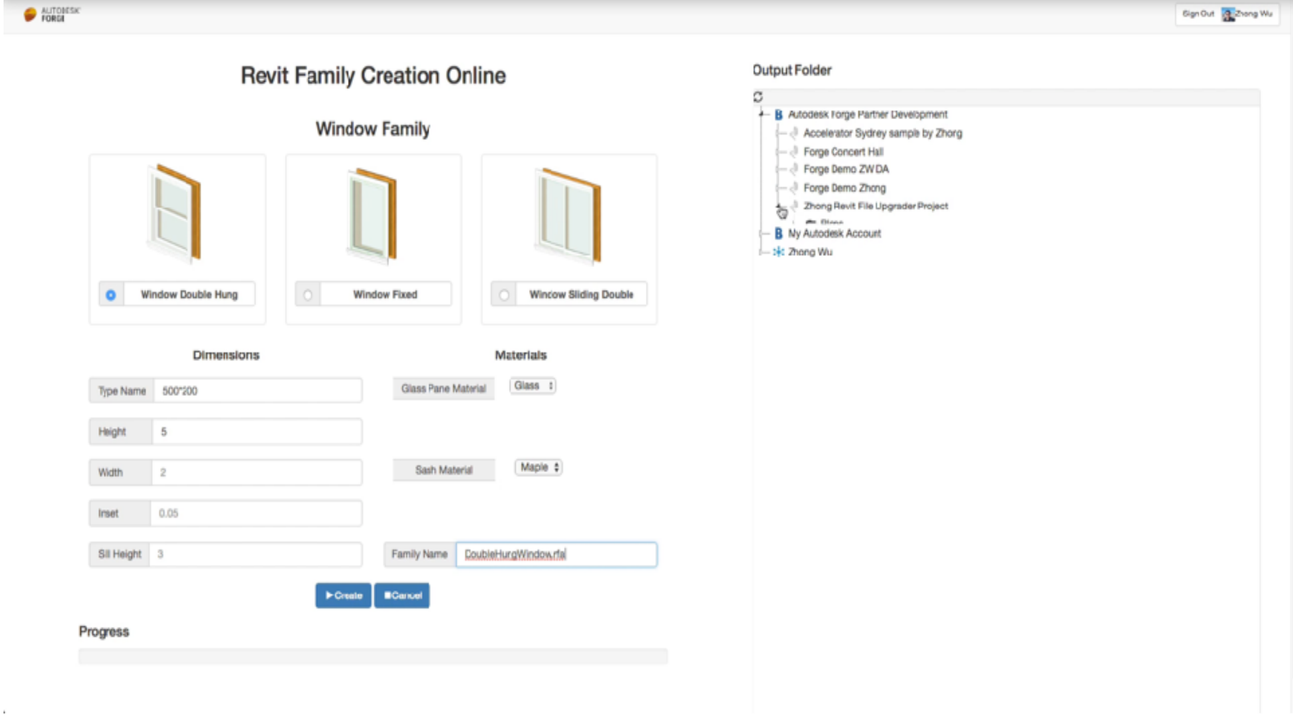


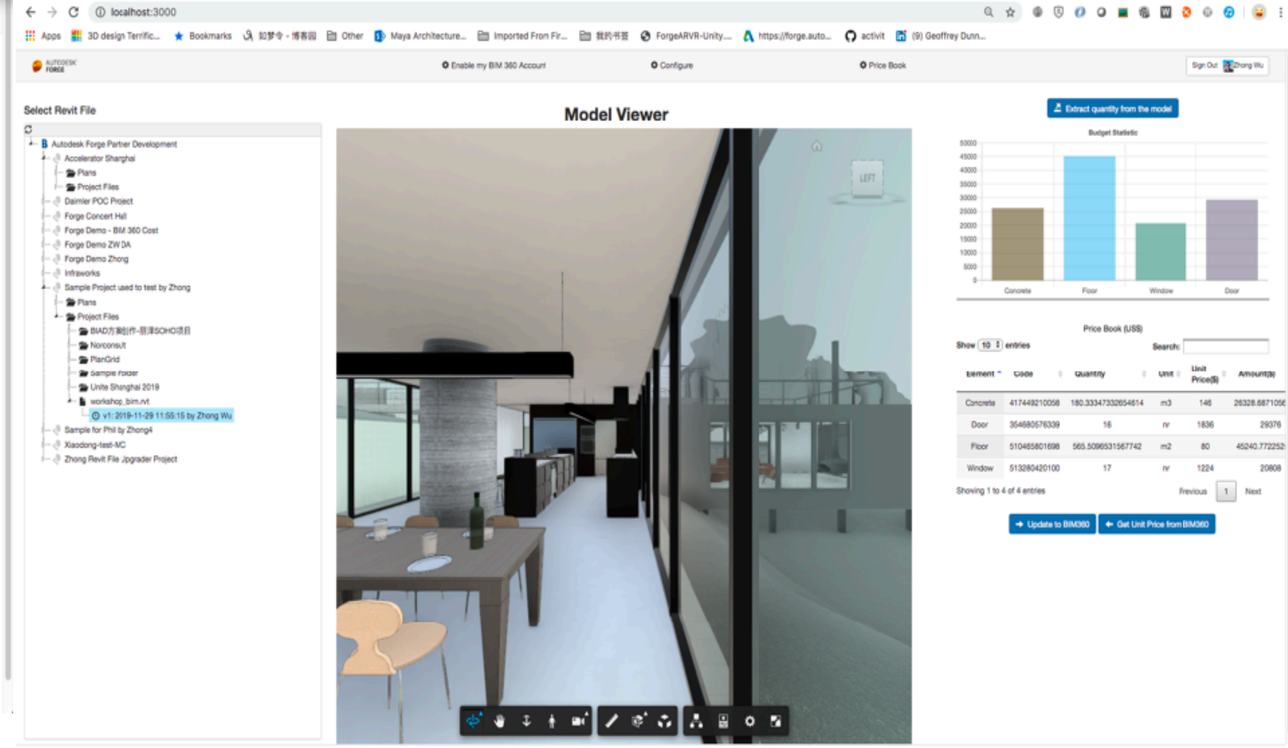
Avoid Pipe/Duct Obstruction - Revit API



- 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







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

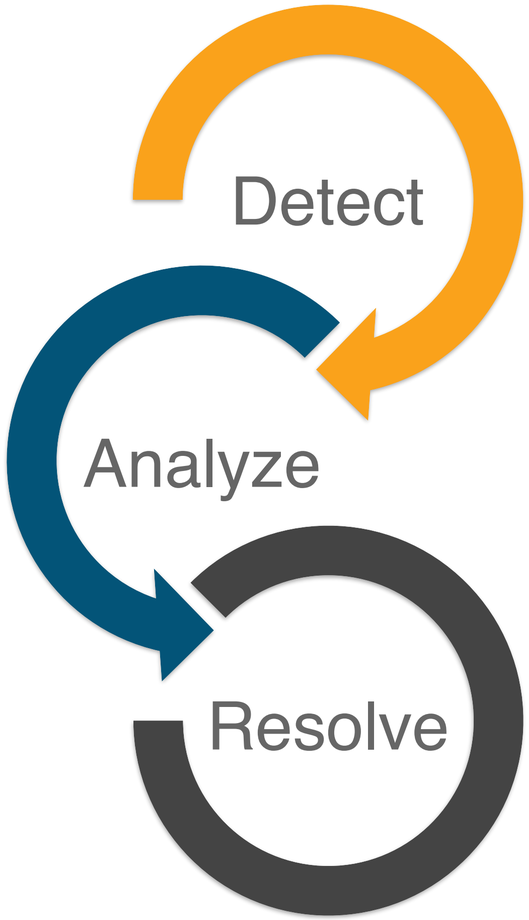
- Getting Started on Design Automation for Revit on Forge
- Automation Workflows with the Forge Design Automation API for Revit
- Design Automation API Tutorials
- Revit Windows Family Creator
- Extract Quantity for Cost Analysis
- Upgrade Revit file Automatically

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

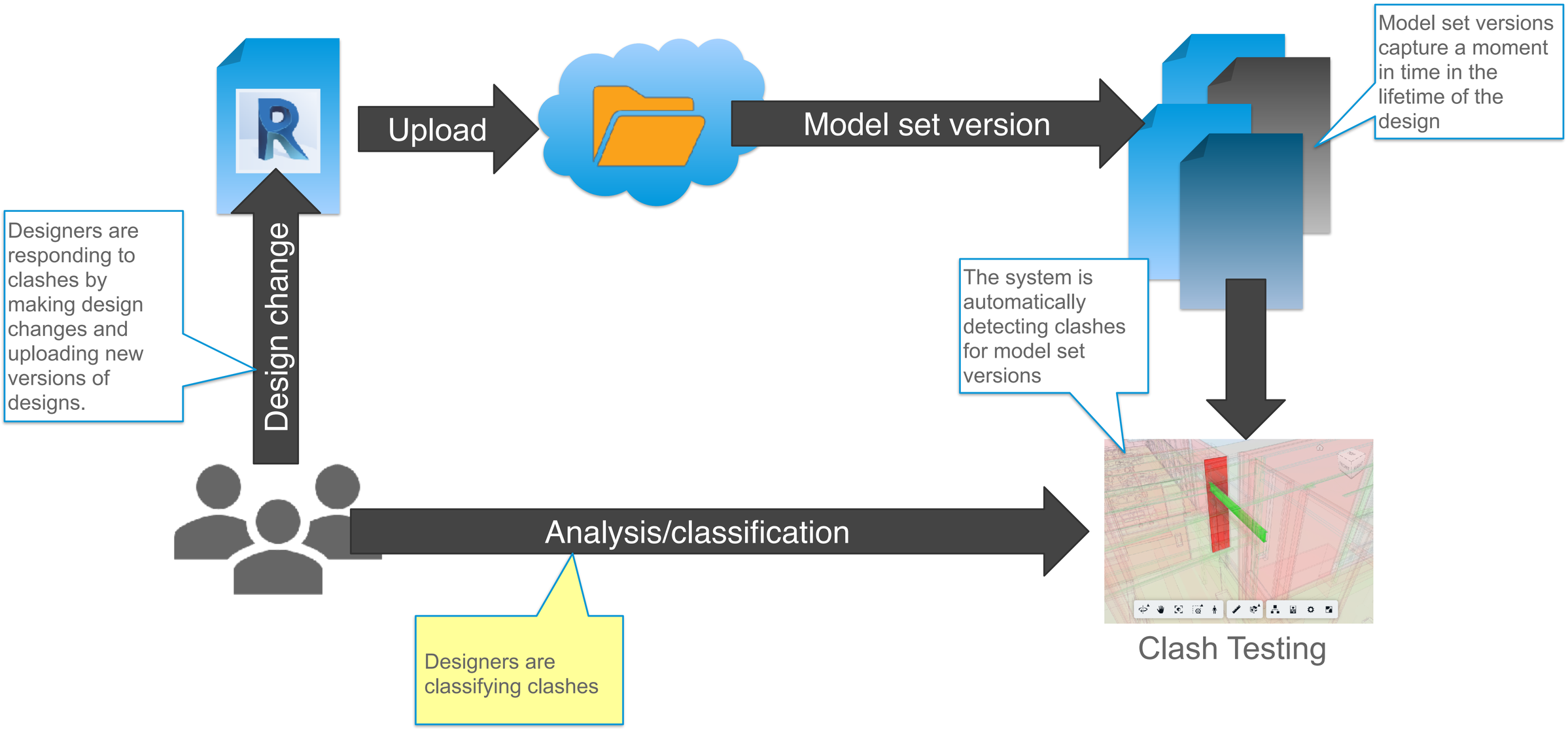
Something small, something useful

Dream project

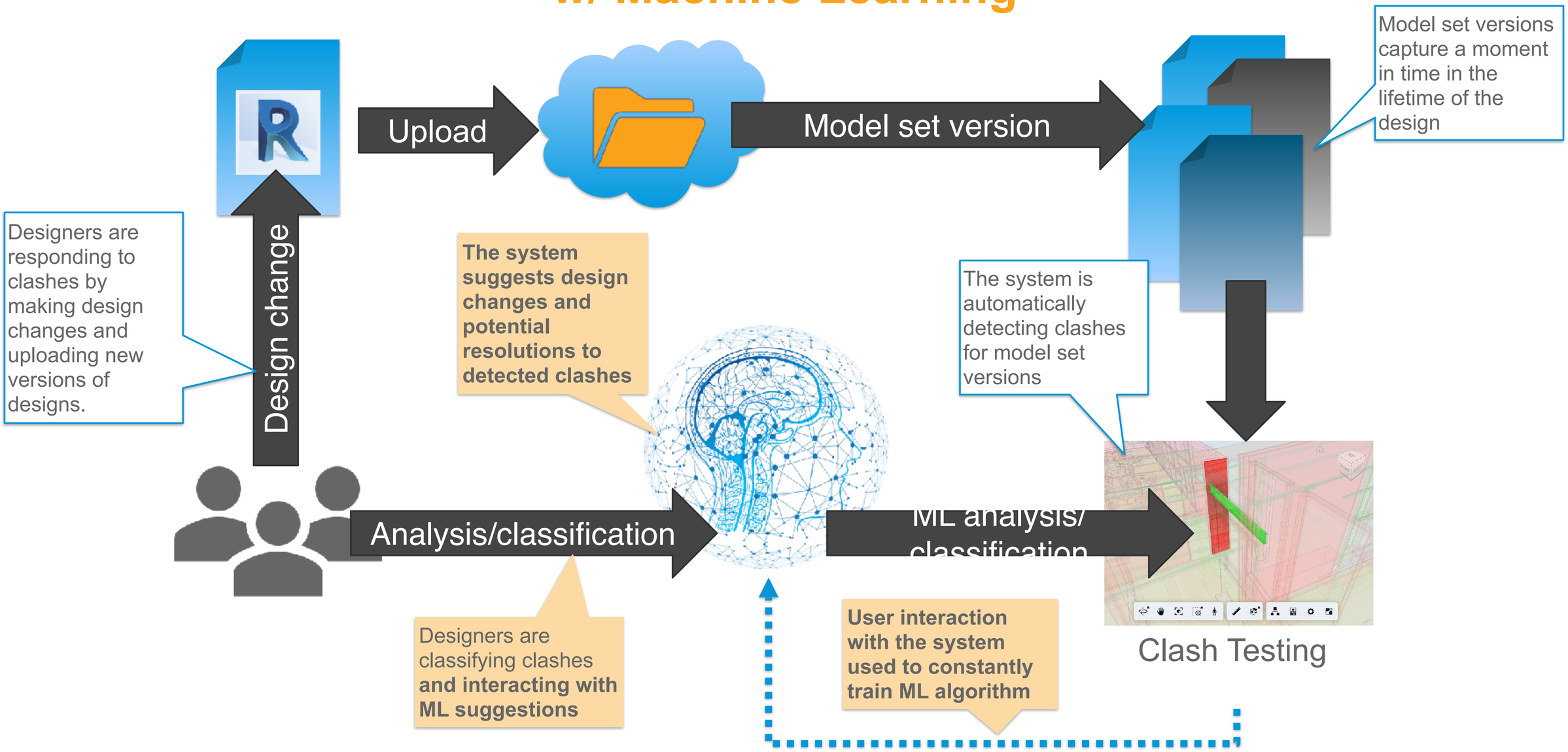
- Suggest potential solution alternatives
- Generative design and optimization
- Machine learning

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