Rationale BIM-Programmierung mit Forge und Vergleich mit der Revit API

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English Handout

This presentation is in German.
The slide deck is in English.
For full English documentation, please
refer to the class handout at

http://thebuildingcoder.typepad.com/blog/2017/10/rational-bim-programming-at-au-darmstadt.html

Key learning objectives

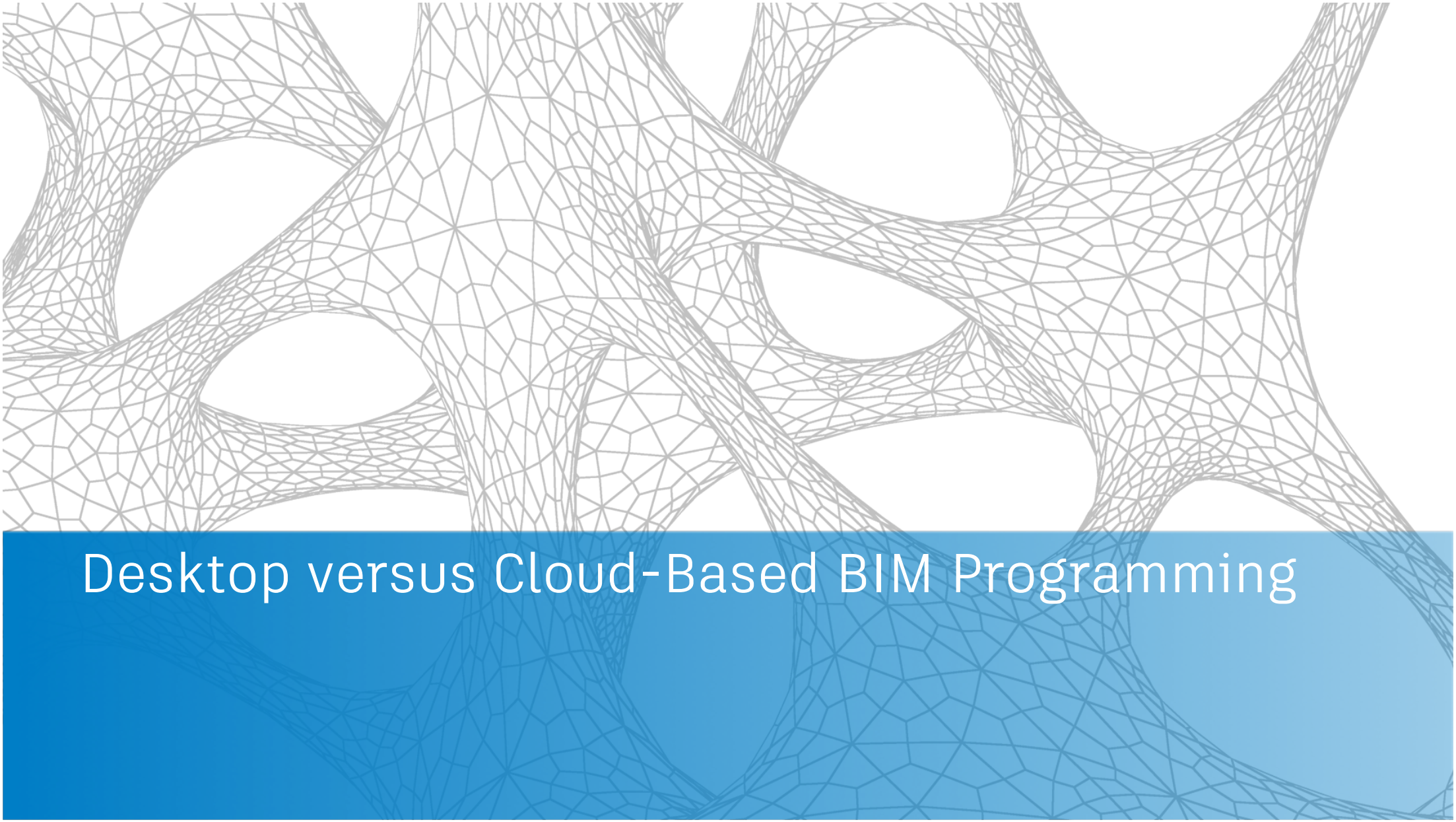
- Envision the most efficient, productive, optimal BIM workflow
- Split software portfolio between desktop add-ins and cloud apps
- Optimal use of Revit, Forge and other programming environments
- Understand pros and cons of commercial, open source and DIY
- Foster ubiquitous connectivity between components
- Enable informed software architecture analysis and design
- Overview of existing samples

Agenda

- Desktop versus Cloud-Based BIM Programming
- Autodesk Forge and Design Automation for Revit
- Using Web Technologies for BIM Programming
- Connecting Desktop BIM and Cloud
- Technologies and Implementation Details
- Resources

Shorter Still...

- Generic BIM programming using web technologies versus Revit-specific add-ins
- BIM connections bridging desktop and cloud to make best use of both worlds



Desktop versus Cloud-Based BIM Programming

Takeaway

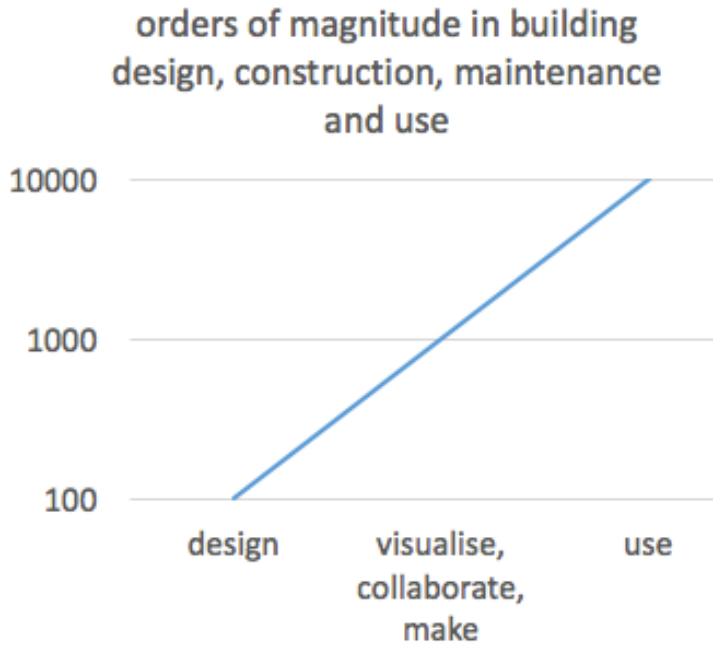
- Split wisely between Revit API and cloud based programming
- Revit is for BIM design
- Many BIM related workflows are read-only
- Many BIM related programming tasks do not require Revit
- Design Automation API for Revit is coming soon

Optimal BIM Workflow

- What is your task?
- Who needs what?
- Where, when, and how?
- Is your user involved in hard-core BIM design work?
- Or, more commonly: view, annotate, adjust, construct, mobile, field work?

BIM Collaboration Roles

- Participant counts grow by orders of magnitude
- Building design, construction, maintenance, use
  - design - architect, engineer - Revit
  - visualise - client, everybody - Viewer
  - collaborate - management – Glue, Plan
  - make - construction – Field, Layout
  - use - inhabit, maintain, FM



Trends, Tools and Technologies

- Revit and BIM Design
  - Expensive
  - Shrinking numbers of desktop computers
- Forge and BIM Use
  - Partially free and open source
  - Growing number of mobile devices
- Glue code, connected custom components
  - Open source libraries
  - JavaScript, HTML5, SVG, WebGL

What Cloud? How Secure?

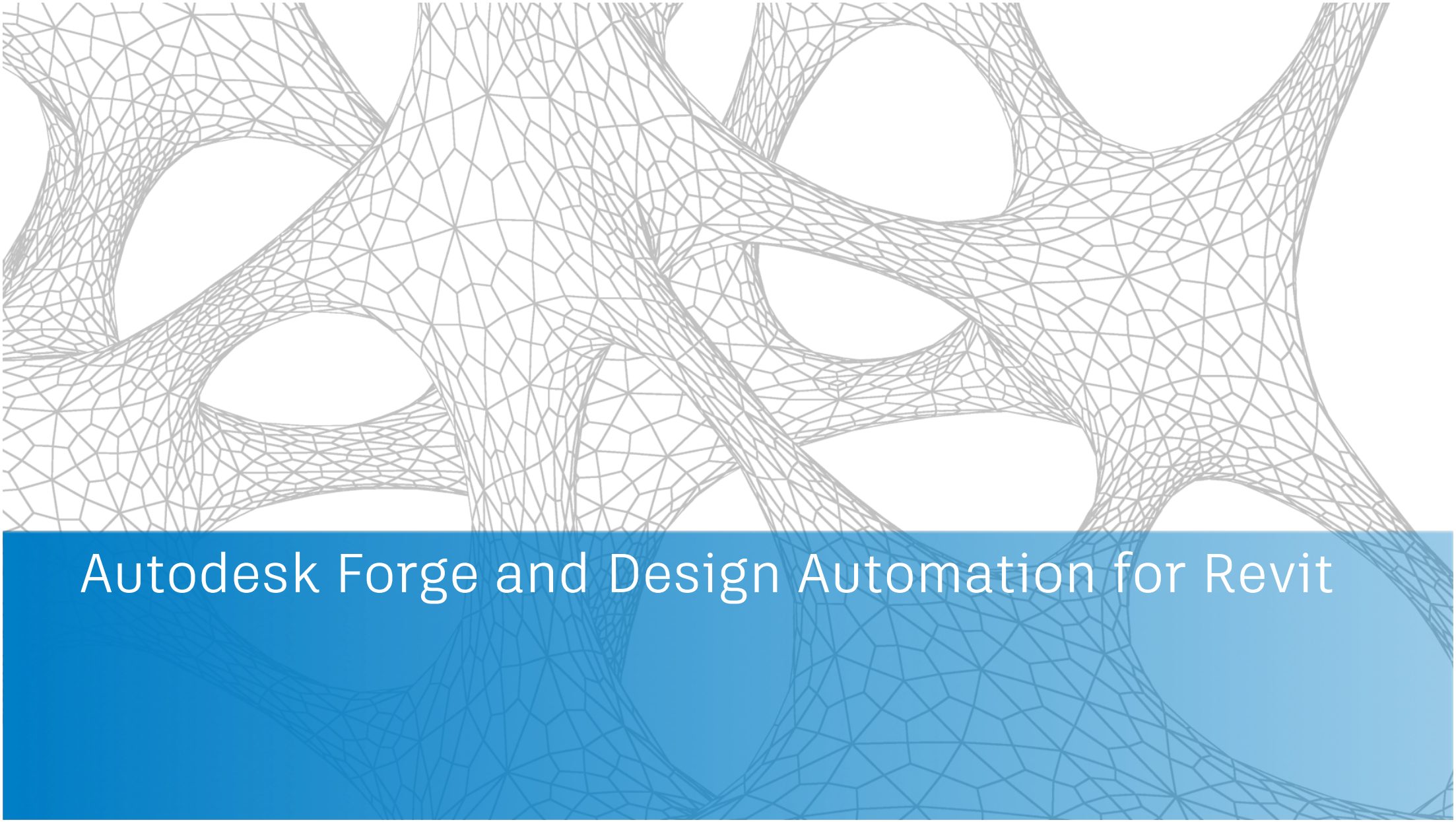
- Locally installed, totally private
  - 2D room editor uses private CouchDB web server
- Global, open source, with standard security measures
  - FireRatingCloud uses node.js web server on Heroku and MongoDB database on mongolab
- Forge OAuth2 user access authorisation
  - Roomedit3dv3

Keep It Simple!

- Simplify your data
  - Graphics? 2D? 3D? Properties?
  - Customise, optimal workflow, minimal complexity
  - Based on 'need to know'
- Use existing components
  - Minimise add-ins, custom components, glue code
  - Open source
  - Forge

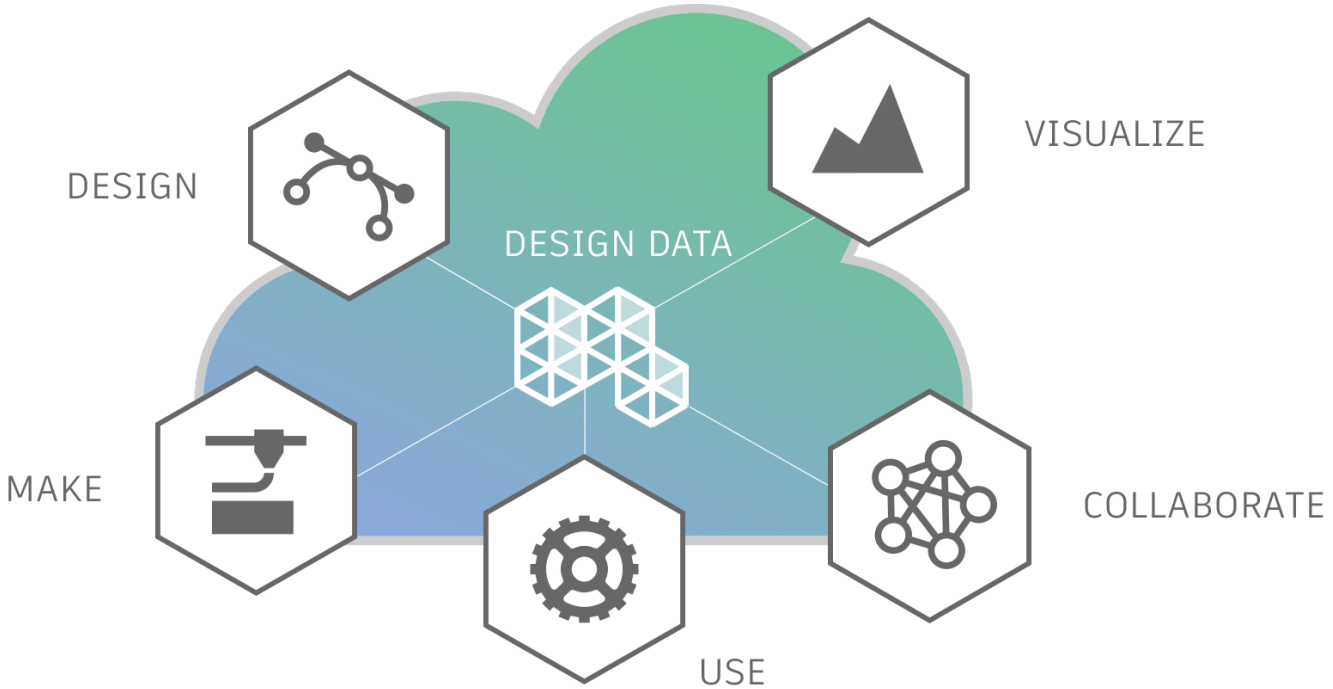
Quotes on Three Fundamental Aspects

- Perfection
  - Perfection is achieved, not when there is nothing more to add, but when there is nothing left to take away – Antoine de Saint-Exupéry
- Lazy
  - … develop the three great virtues of a programmer: laziness, impatience, and hubris – Larry Wall
- Simple
  - Simplicity is the ultimate sophistication – Leonardo da Vinci
  - There is no greatness where there is no simplicity – Leo Tolstoy
- KISS


Autodesk Forge and Design Automation for Revit

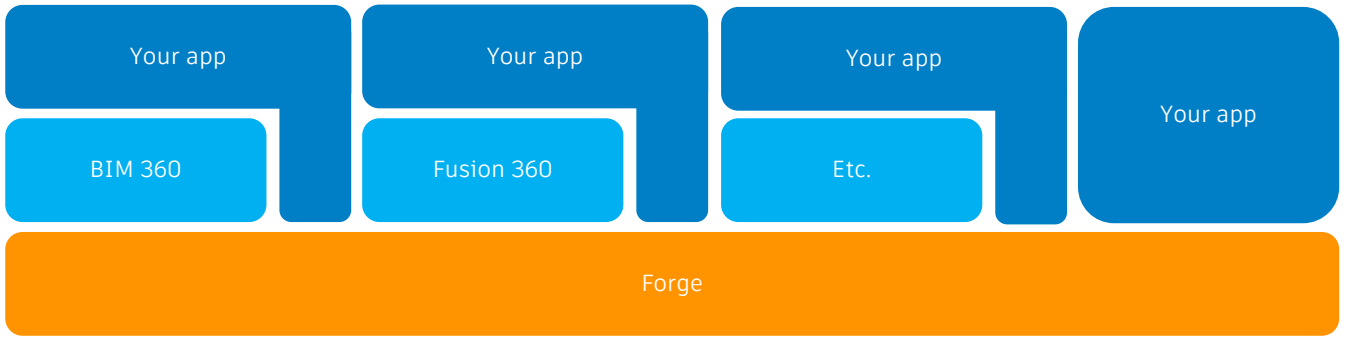
Forge Empowers Developers to Empower Users

- Forge is a platform to empower developers
- They can in turn empower their users
  - design
  - visualise
  - collaborate
  - make
  - use



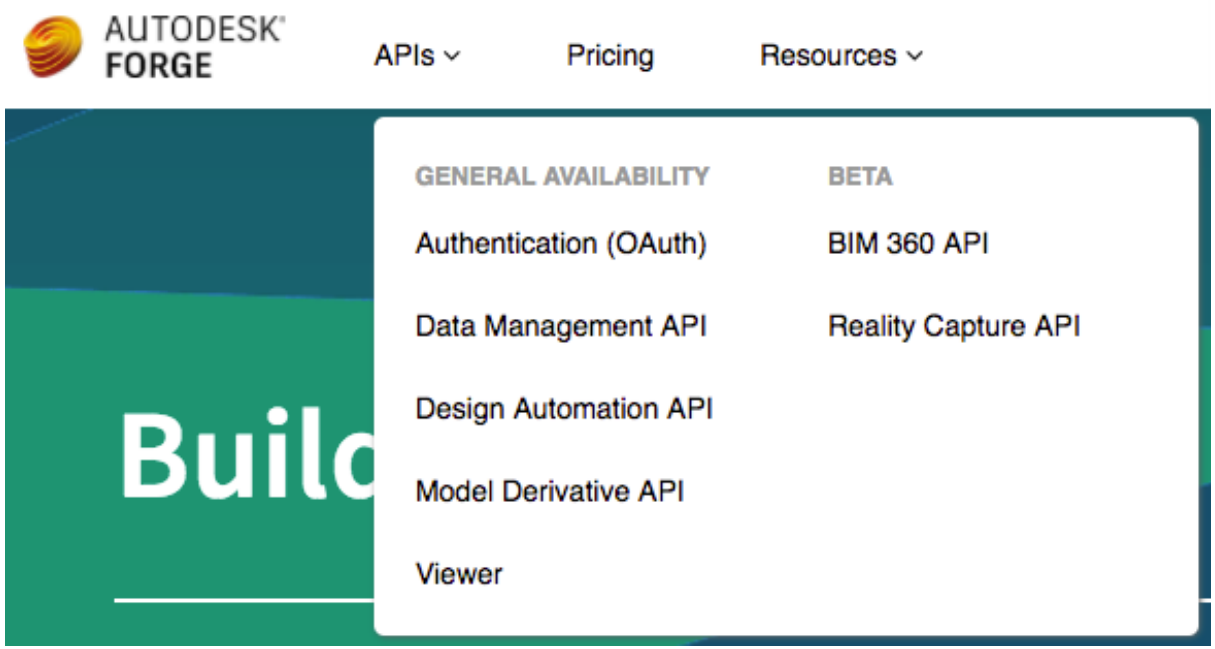
Forge is a Platform

- Autodesk uses Forge to build its products
- Your application has access to the same APIs



Forge APIs

https://autodesk-forge.github.io



Create or Manipulate BIM in the Web

- Do not misuse Revit as a server
- It is an end user product
- If you have such a requirement, talk with Autodesk
  http://thebuildingcoder.typepad.com/blog/about-the-author.html#5.28b

Forge APIs in the Past

- 3 years ago

Share	Collaborate	Create
Translation API		
Viewer		

Forge APIs at Present

- Today, 'Forge 2.0'

Share	Collaborate	Create
Model Derivative API	BIM 360 HQ API	Design Automation - AutoCAD
Viewer	Data Management API	

Forge APIs Near Future

- Next year, 'Forge 3.0'

Share	Collaborate	Create
Model Derivative API	Data Management API	Design Automation - AutoCAD
Viewer	Webhooks API	Design Automation - Revit
	BIM APIs (HQ, RFIs, Issues, Checklists)	Design Automation – Inventor
		Photo-to-3D API
		Forge IDX

Design Automation for Revit

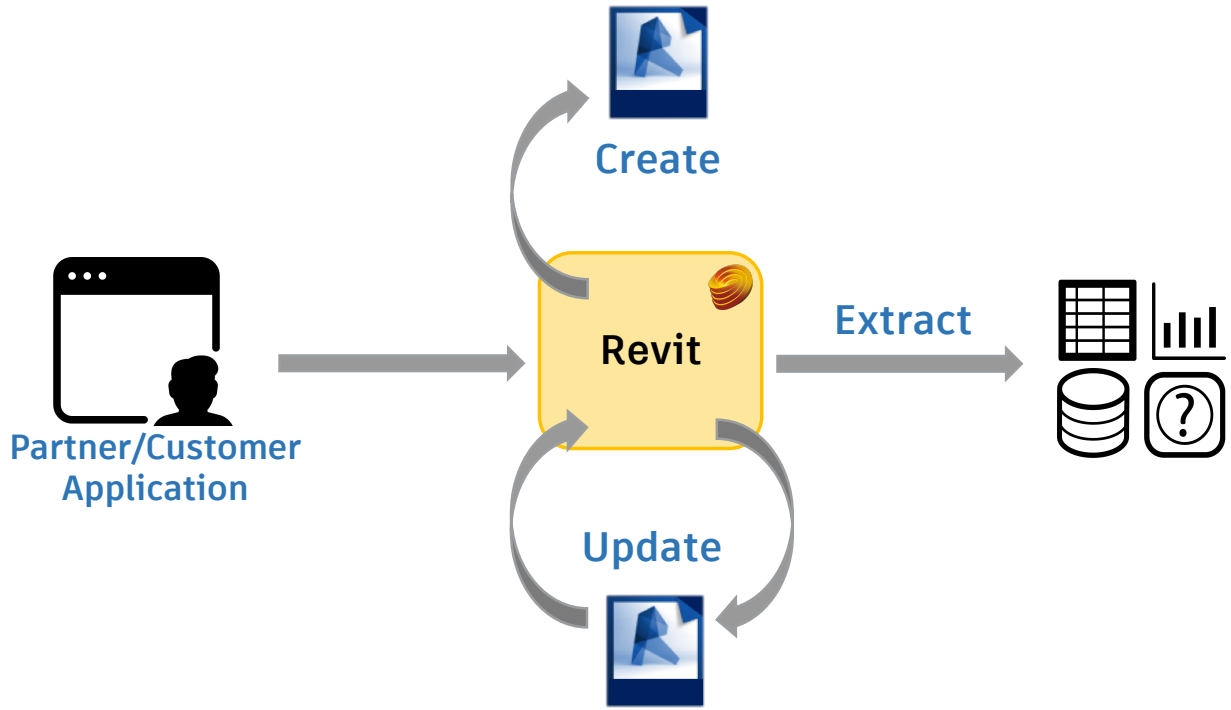
- What is the value?

For Partners	• Create and deploy services and apps that leverage partner's core competencies to **enhance customer workflows**
For Customers	• Quickly extend Revit-based workflows to **solve specific business problems**
For Autodesk	• Facilitate the creation of **new cloud-based solutions** to common customer problems

What Can and Can't It Do?

- What can it do?
  - Full access to Revit DB API outside Revit via cloud services
  - Execute .NET add-ins and Dynamo scripts
  - Access custom functionality while operating on a Revit model
  - Read data from anywhere, save data anywhere
- What can’t it do?
  - No “sticky sessions” – only batch operations
  - Access live Revit data in a RESTful way
  - No Revit UI API access – there is no UI!

Workflows


Create
Partner/Customer
Application
Revit
Extract
Update

Workflow 1 – Create

Use Cases

- Create families (RFAs) from a catalog
- Create RVTs from layout app
- Stair layout generator
- Convert from third party format to RVT/RFA
- Generate full documentation from specification

Hypothetical Example

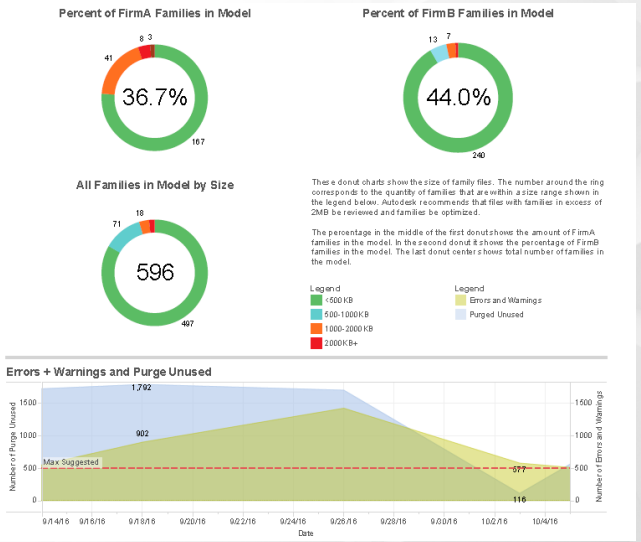
AUTODESK® FORGE

Workflow 2 – Extract

Use Cases

- Custom extraction (Excel, private database, unsupported formats, etc)
- Automated extraction (e.g. nightly PDF or DWG)
- Model QA/QC & code checks
- Clash detection
- Share model information with consultants without need for Revit

Hypothetical Example



AUTODESK® FORGE

Workflow 3 – Update

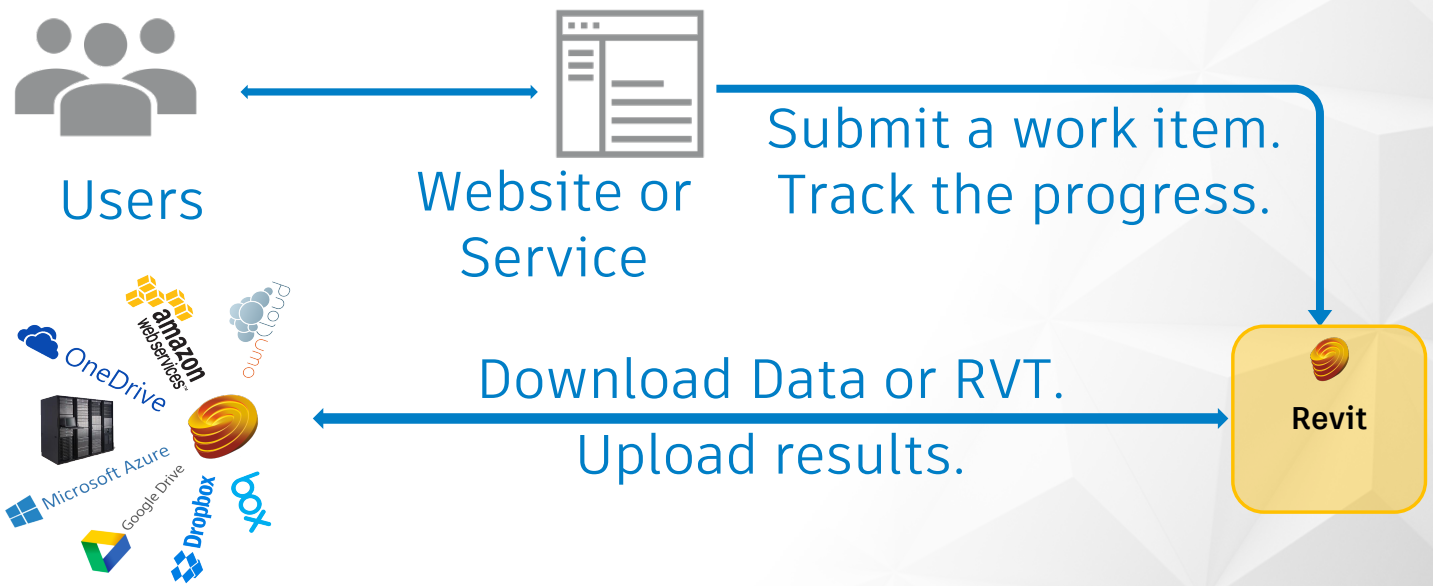
Use Cases

- Execute nightly model tasks on C4R models
- Fix common modeling and documentation mistakes
- Batch upgrades & updates
- Automatically replace out-of-date content
- Scheduled Dynamo scripts
- Design option generation
- And many more!

Hypothetical Example

AUTODESK® FORGE

How Does It Work?



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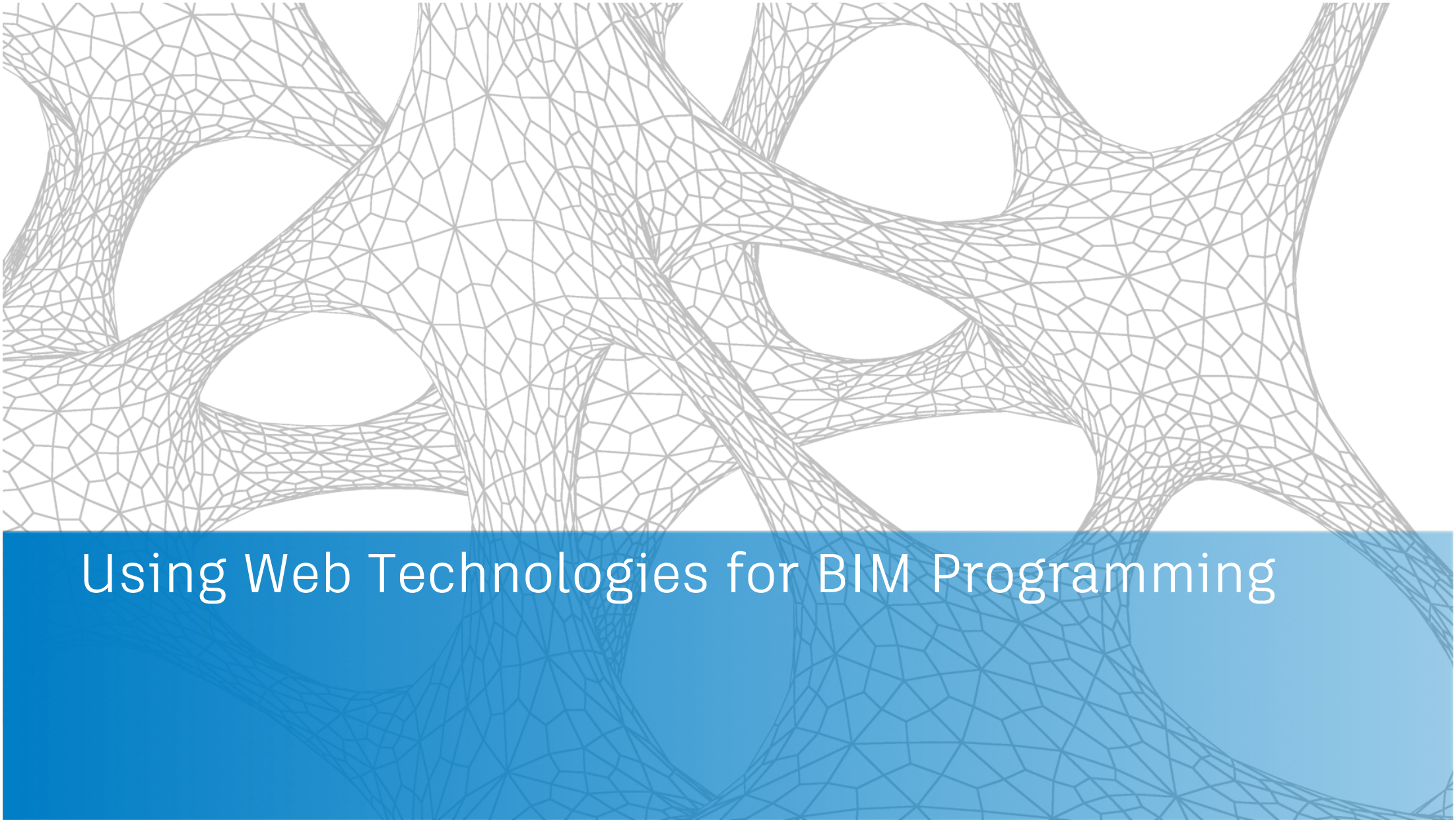


Using Web Technologies for BIM Programming

Web-Based BIM Programming Opportunities

- Revit API is BIM and end user product specific
- Many BIM related tasks can be solved more generically

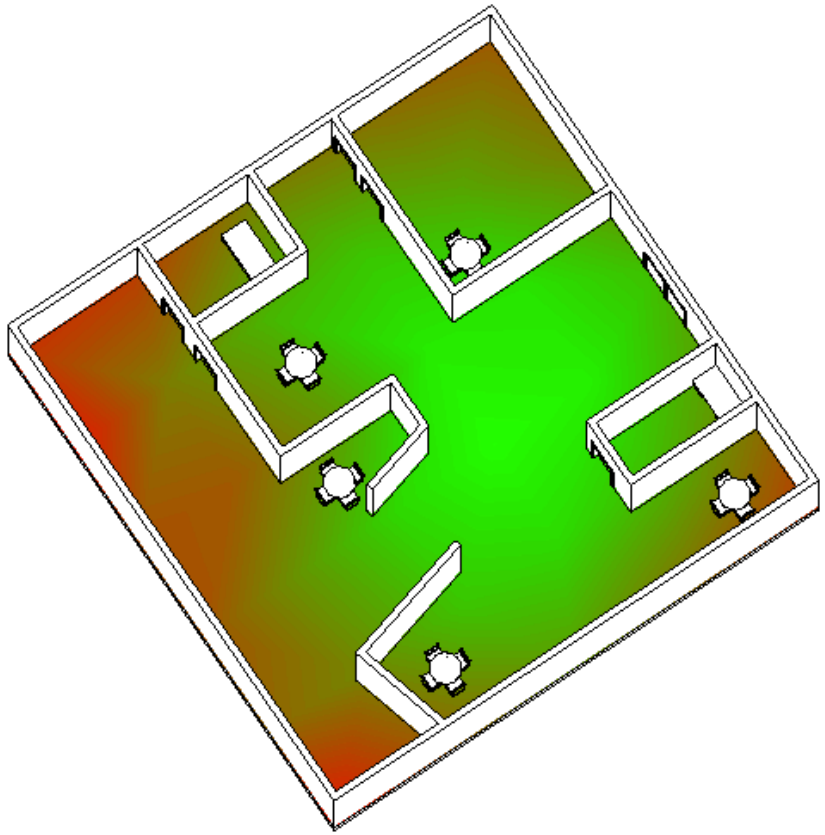
Revit API Characteristics and Limitations

- Revit API is BIM specific
- Very powerful in certain areas
- Leverages Revit product functionality

Therefore:

- Making use of it requires Revit product understanding
- It works only within a running Revit session
- It is completely event driven, hard to 'drive from outside'
- It is limited to the UI oriented Revit end user product
- Programming it requires special training
- Using a Revit add-in requires a Revit installation

Ex: Calculate and Display Signal Attenuation



RvtFader

- C# .NET Revit add-in
- Calculate and display signal attenuation

https://github.com/jeremytammik/RvtFader

- The Analysis Visualisation Framework AVF
- Ray tracing using ReferenceIntersector

ForgeFader

- Forge viewer extension app

  https://github.com/jeremytammik/forgefader

- Demo

  https://forge-rcdb.autodesk.io/configurator > Meta Properties
  https://forge-rcdb.autodesk.io/configurator?id=59041f250007f5c0eef482f2

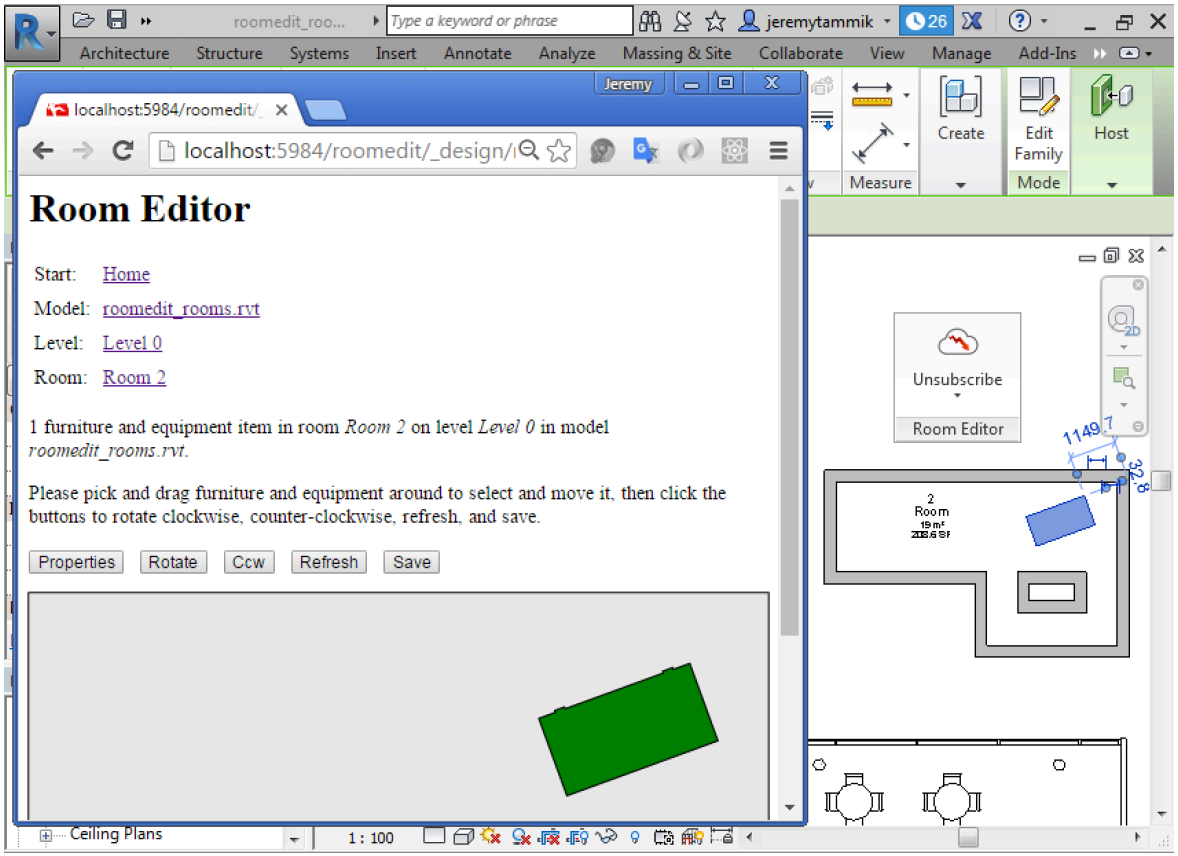
- JavaScript
- Three.js
- Custom shader

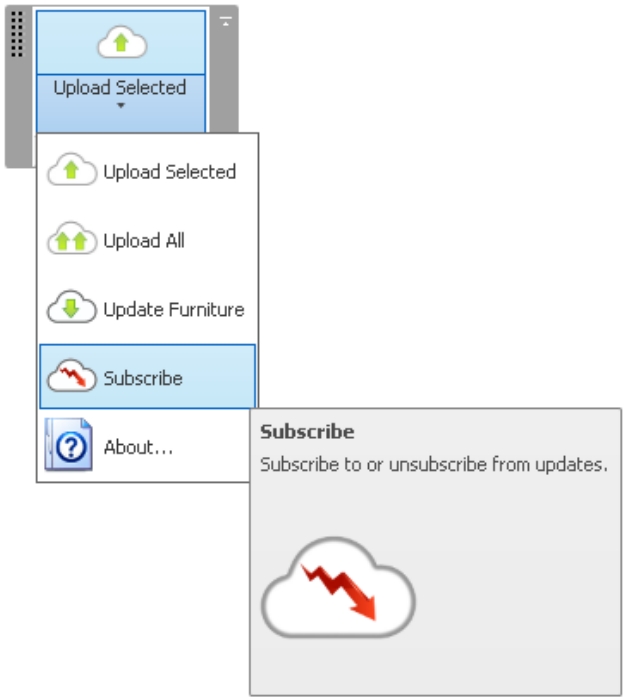

Connecting Desktop BIM and Cloud

Sample Overview

- Simplified 2D BIM room editor, SVG graphics
- FireRating in the Cloud, the simplest sample
- Roomedit3d, Forge based 2D + 3D simplified round-trip BIM editor
- Forge meta property editor + RvtMetaProp

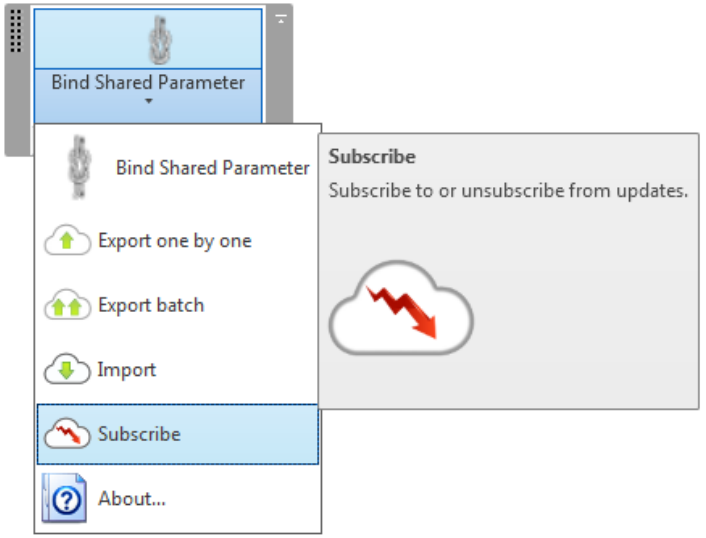
2D Room Editor



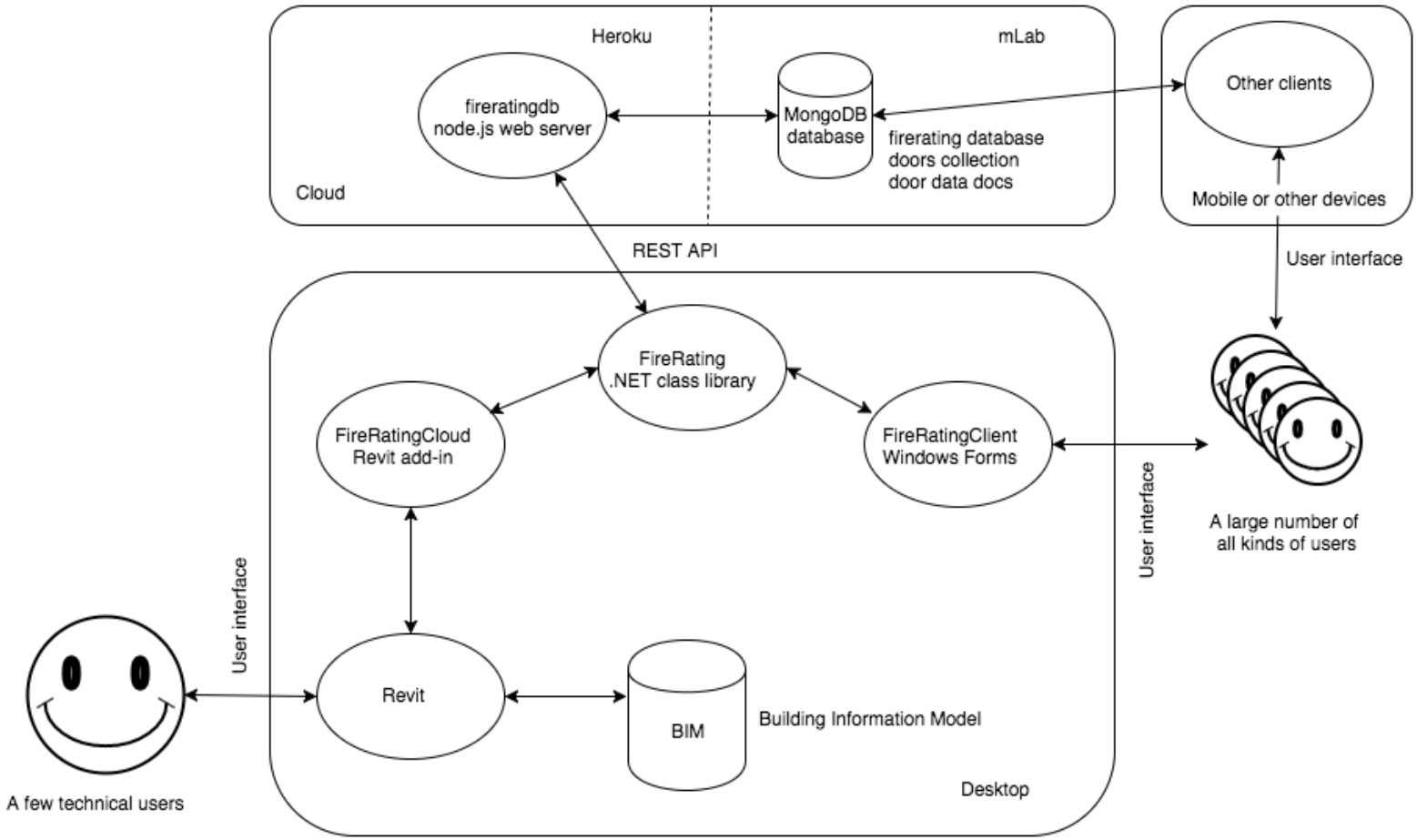


FireRating in the Cloud Commands

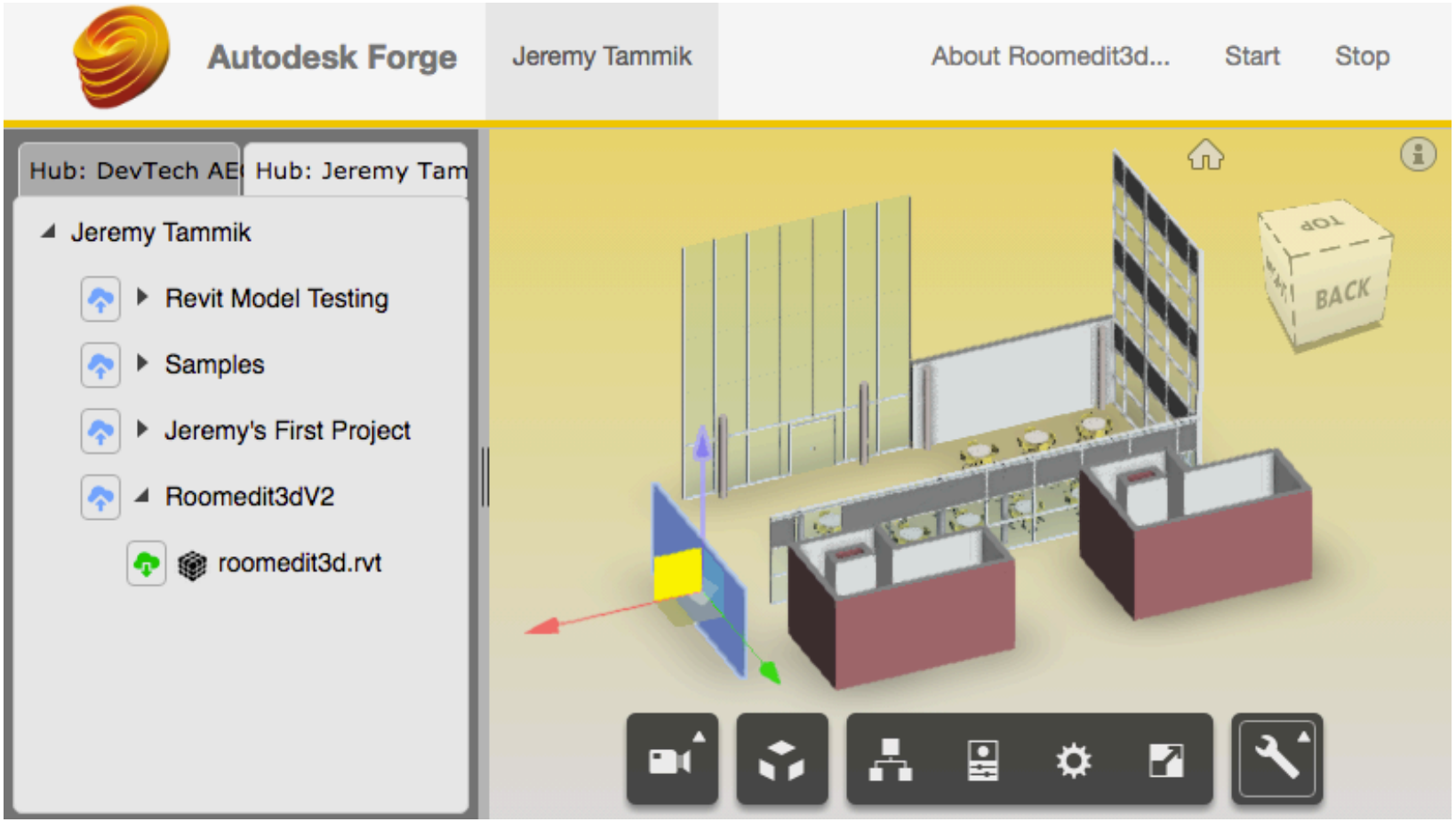
- Create the shared 'Fire Rating' parameter
- Export fire rating values for all doors
- Import the modified values back into BIM
- Store data for multiple projects
  - Cloud database, Revit UniqueId
- Subscribe to changes



FireRating in the Cloud Architecture



Forge Based BIM Editor



Advantages of a Forge Based App

- Realistic model rendering in both 2D and 3D, optionally linked
- Complete access to all BIM data, geometry, structure, properties
- Not bound to any specific model
- Secure authenticated access
- Embedded in a full ecosystem of mature CAD related web services
- Minimal amount of coding based on boilerplate sample code

Forge Meta Property Editor

- https://forge-rcdb.autodesk.io/configurator
- Meta Properties
- Use Model: Office

https://forge-rcdb.autodesk.io/configurator?id=59780eec17d671029c53420e

- Add and edit custom properties on elements in Forge viewer
- Download custom property data in CSV or JSON

RvtMetaProp

https://github.com/jeremytammik/rvtmetaprop

- Read custom property data in CSV or JSON
- Associated with individual building elements
- Modify existing element parameter data
- Generate shared parameters for new
- Requires suitable category sets


Technologies and Implementation Details

NoSQL

- “Not only SQL”
  - Next generation database paradigm
- Some characteristics
  - Non-relational, distributed, open-source, scalable, huge data
- Frequent other characteristics
  - Schema-free, easy replication support, simple API, eventually consistent, i.e., BASE, not ACID
    - http://nosql-database.org
    - https://en.wikipedia.org/wiki/NoSQL
    - http://www.mongodb.com/nosql-explained

CAP and ACID versus BASE

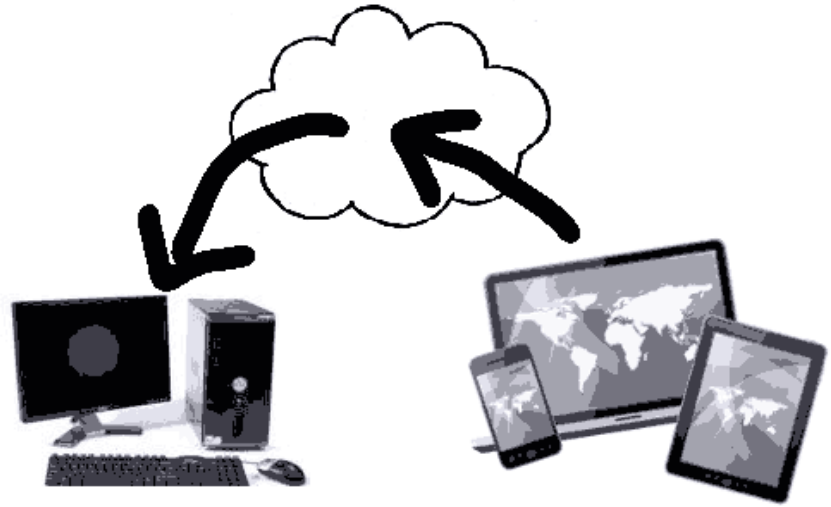
- ACID
  - Atomicity, Consistency, Isolation and Durability guarantee that database transactions are processed reliably
- CAP Theorem
  - The ACID paradigm cannot simultaneously guarantee consistency, availability and partition tolerance (distributed system)
- BASE
  - Basic Availability, Soft-state, Eventual consistency

http://thebuildingcoder.typepad.com/blog/2014/05/views-displaying-given-element-svg-and-nosql.html#5

Data Source, Repository and Consumer Client

- BIM – Building Information Model
- Cloud-based data repository
- 2D rendering on mobile device

Real-time Edit Triggers Database and BIM Update



- Graphical room editor on mobile device
- Update cloud database
- Reflect real-time changes in BIM

CouchDB Database Implementation

- Everything is a document
- All documents are JSON
- Every document has built-in id and revision
- The database design is also a document
- The design defines views and attachments

BIM Model

- Model – a RVT project file
- Level
- Room
- FamilyInstance – furniture or equipment
- FamilySymbol – geometry

BIM Object Graphics

- Room has boundary loops and can contain holes
- FamilySymbol has a single boundary loop
- FamilyInstance has a 2D placement
  - Translation
  - Rotation

BIM Object Relationships

- CouchDB ids are Revit unique ids
- Family instance → room → level → model
- Family instance → symbol

NoSQL Database Structure

- DbObj base class
- DbModel
- DbLevel
- DbRoom
- DbFurniture
- DbSymbol

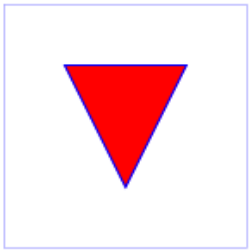
Database Object Relationships

- DbFurniture.symbolId → DbSymbol
- DbFurniture.roomId → DbRoom
- DbRoom.levelId → DbLevel
- DbLevel.modelId → DbModel

Database Object Graphics and Placement

- All graphics represented by SVG path element data

```
<svg width="4cm" height="4cm" viewBox="0 0 400 400"
    xmlns="http://www.w3.org/2000/svg" version="1.1">
  <rect x="1" y="1" width="398" height="398"
      fill="none" stroke="blue" />
  <path d="M 100 100 L 300 100 L 200 300 z"
      fill="red" stroke="blue" stroke-width="3" />
</svg>
```



JSON Symbol Database Document

- Family symbol
- Define geometry


```
{
  "_id": "11cc6e52-519e-49b2-9813-c9561b59a1fd-0005f5fc",
  "_rev": "1-d575ca095533db4ccbed9f7ab2607a12",
  "loop": "M-191 922 L190 922 216 862 190 859 -191 859 -216 862 -216 919Z",
  "type": "symbol",
  "description": "FamilySymbol Furniture <390652 Table ronde a chaises>",
  "name": "Table ronde avec chaises - 01"
}
```

JSON Instance Database Document

- Furniture doc represents family instance and defines
- Relationship to room and family symbol
- Placement = transform = translation + rotation


```
{
  "_id": "11cc6e52-519e-49b2-9813-c9561b59a1fd-0005f65b",
  "_rev": "1-c1b4fc969181267b55dab4c6857fc5d7",
  "roomId": "cbe571b0-0593-4350-a8e6-abf3c9239325-00061210",
  "symbolId": "11cc6e52-519e-49b2-9813-c9561b59a1fd-0005fe6d",
  "transform": "R-90T-10429,1020",
  "type": "furniture",
  "description": "FamilyInstance Furniture <390747 Canapé...
  "name": "Canapé 3 places"
}
```

CouchDB Views

- A view defines a map and optional reduce function
- The map produces key-value pairs
- Reduce produces an accumulation

```
exports.models = {
  map: function (doc) {
    if( 'model' == doc.type ) {
      emit(doc, null);
    }
  },
  reduce: function (key, values, rereduce) {
    return sum(values);
  }
}
```

Room Editor Views

- models
- levels
- rooms
- furniture
- symbols
- map_room_to_furniture
- map_level_to_room
- map_model_to_level

```
rooms = {
  map: function (doc) {
    if( 'room' == doc.type ) {
      emit(doc, null);
    }
  }
};
```

```
map_level_to_room = {
  map: function (doc) {
    if( 'room' == doc.type ) {
      emit(doc.levelId, doc);
    }
  }
};
```

Minimal Predefined HTML Scaffolding

- <h1>Room Editor</h1>
-
- <ul id="navigatorlist">
-
-
- <script type="text/javascript" src="modules.js"></script>
- <script type="text/javascript" src="raphael-min-jt.js"></script>

- Populated entirely using JavaScript adding HTML and SVG nodes using jquery, raphael and db for CouchDB queries

Resources

Full Documentation

Please refer to the class handout documentation at

http://thebuildingcoder.typepad.com/blog/2017/10/rational-bim-programming-at-au-darmstadt.html

Old Sample Repositories

- 2D RoomEditorApp and roomeditdb

  https://github.com/jeremytammik/RoomEditorApp
  https://github.com/jeremytammik/roomedit

- FireRatingCloud and fireratingdb

  https://github.com/jeremytammik/FireRatingCloud
  https://github.com/jeremytammik/firerating

- Roomedit3dApp, roomedit3d and roomedit3dv3

  https://github.com/jeremytammik/Roomedit3dApp
  https://github.com/jeremytammik/roomedit3d
  https://github.com/Autodesk-Forge/
  forge- boilers.nodejs/tree/roomedit3d

New Sample Repositories and Demos

- RvtFader
  https://github.com/jeremytammik/RvtFader
- ForgeFader
  https://github.com/jeremytammik/forgefader
  https://forge-rcdb.autodesk.io/configurator > Meta Properties
  https://forge-rcdb.autodesk.io/configurator?id=59041f250007f5c0eef482f2
- RvtMetaProp
  https://github.com/jeremytammik/rvtmetaprop

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Make anything.