AUTODESK UNIVERSITY

Beyond Dynamo: the powerful automation potential of Forge and the Revit API

Majd Makhlouf

Founding Manager – BIRD OÜ | @bird_tools

About The Speaker

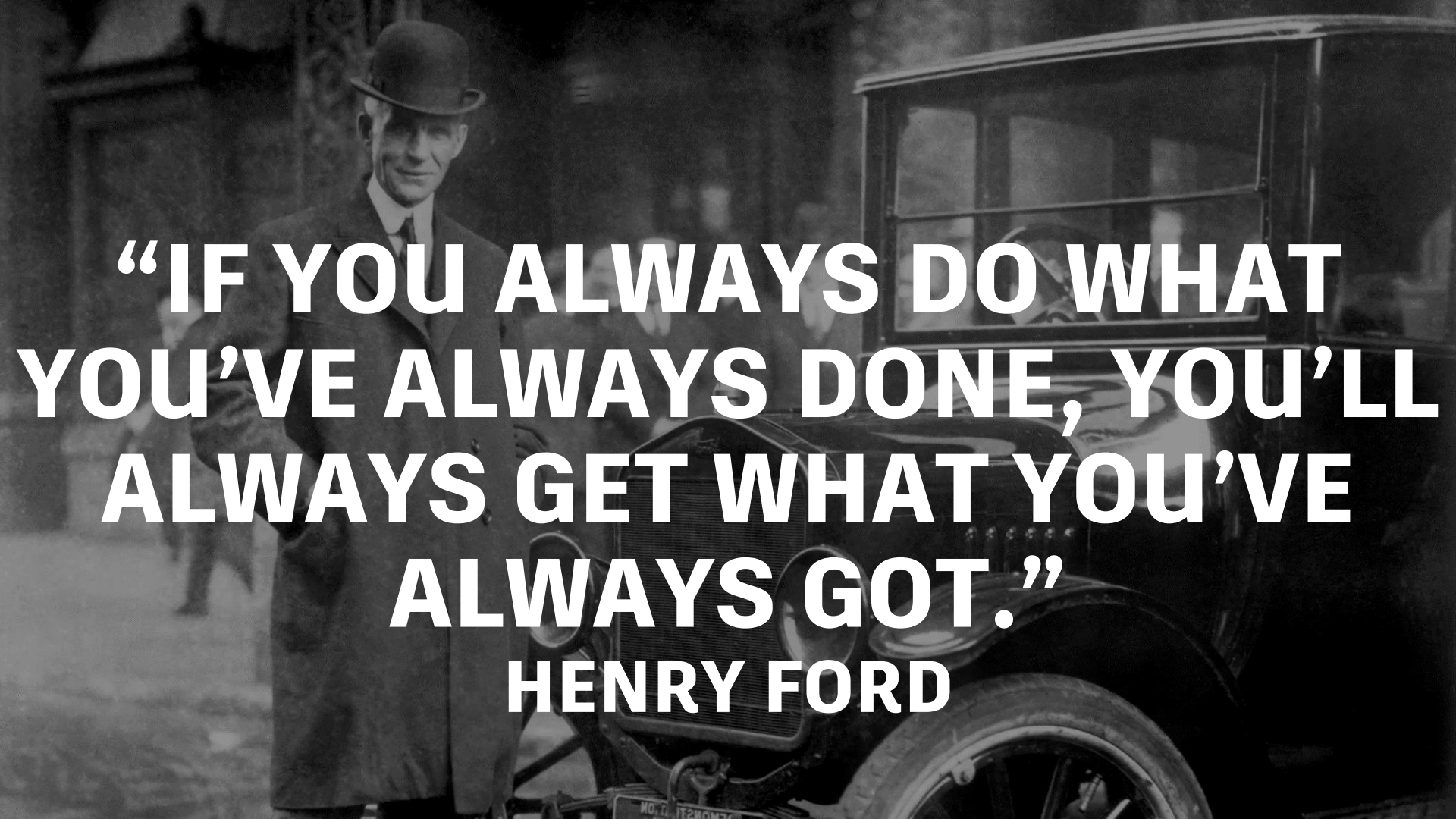
Majd Makhlouf

- Master of Science in Mechanical Engineering.
- Design Technologist and Developer
- Member of the Autodesk Developer Network
- Founder at **B**uilding **I**nformation **R**esearchers and **D**evelopers OÜ (a.k.a Bird Tools)

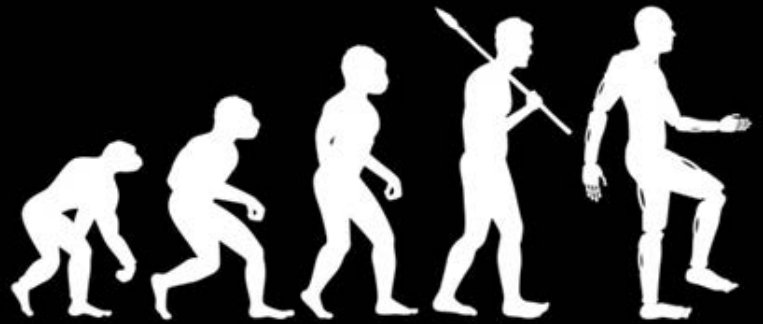
Joining me this year…

Ghida Shehadeh

- Bachelor’s Degree in Electrical & Computer Engineering.
- Teacher and Research Assistant in the wireless communication and IoT fields.
- Co-Author of the IEEE Paper “TU-SP.2P.7”.
- Electrical Engineer at EMDC Group

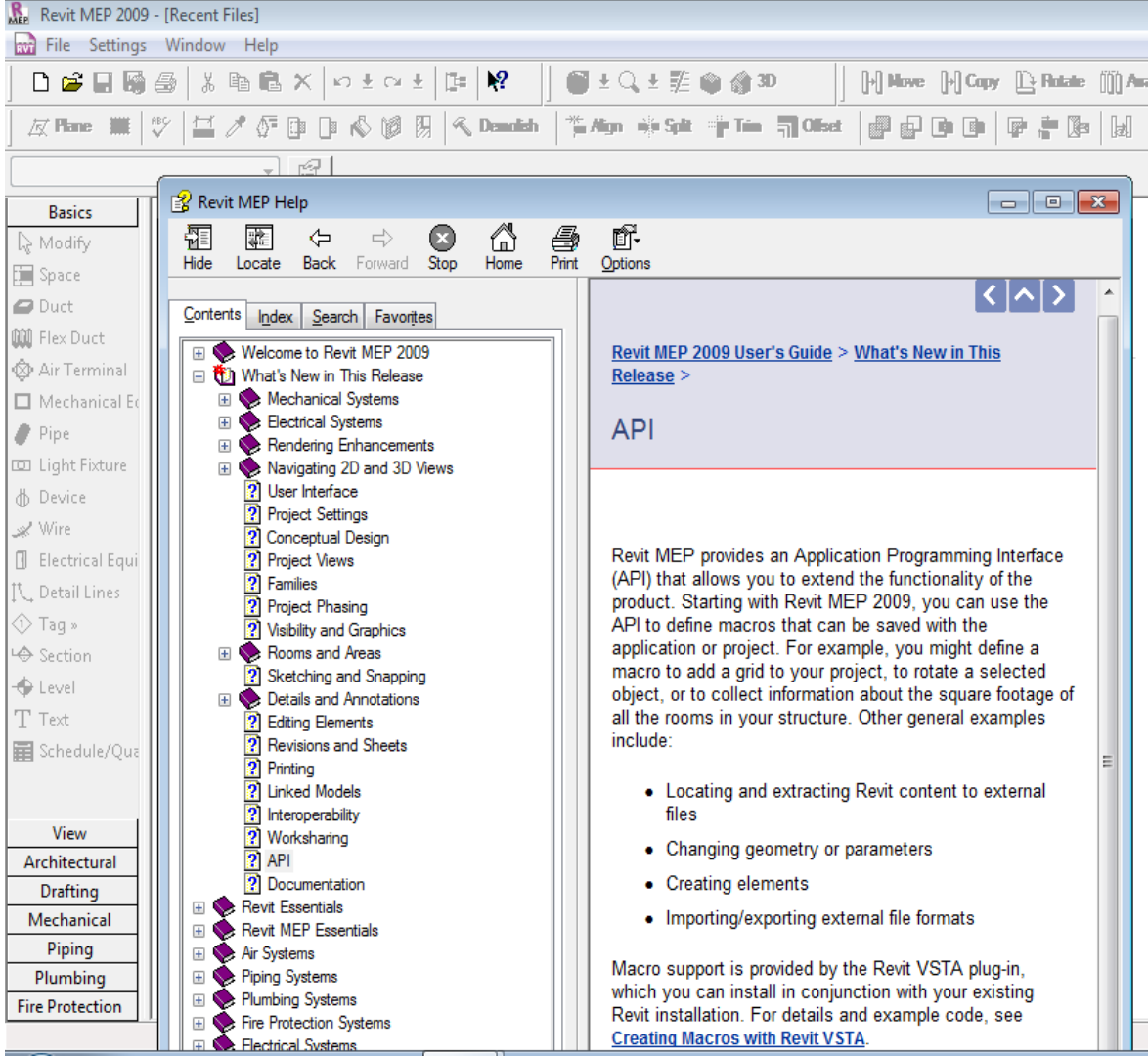

“IF YOU ALWAYS DO WHAT YOU’VE ALWAYS DONE, YOU’LL ALWAYS GET WHAT YOU’VE ALWAYS GOT.”
HENRY FORD

REVIT AUTOMATION: A HISTORIC OVERVIEW



2009 – A NEW ERA

- **REVIT 2009: A MAJOR RELEASE**
- **INTRODUCED WITH REVIT 2009 WAS A PUBLIC API…**



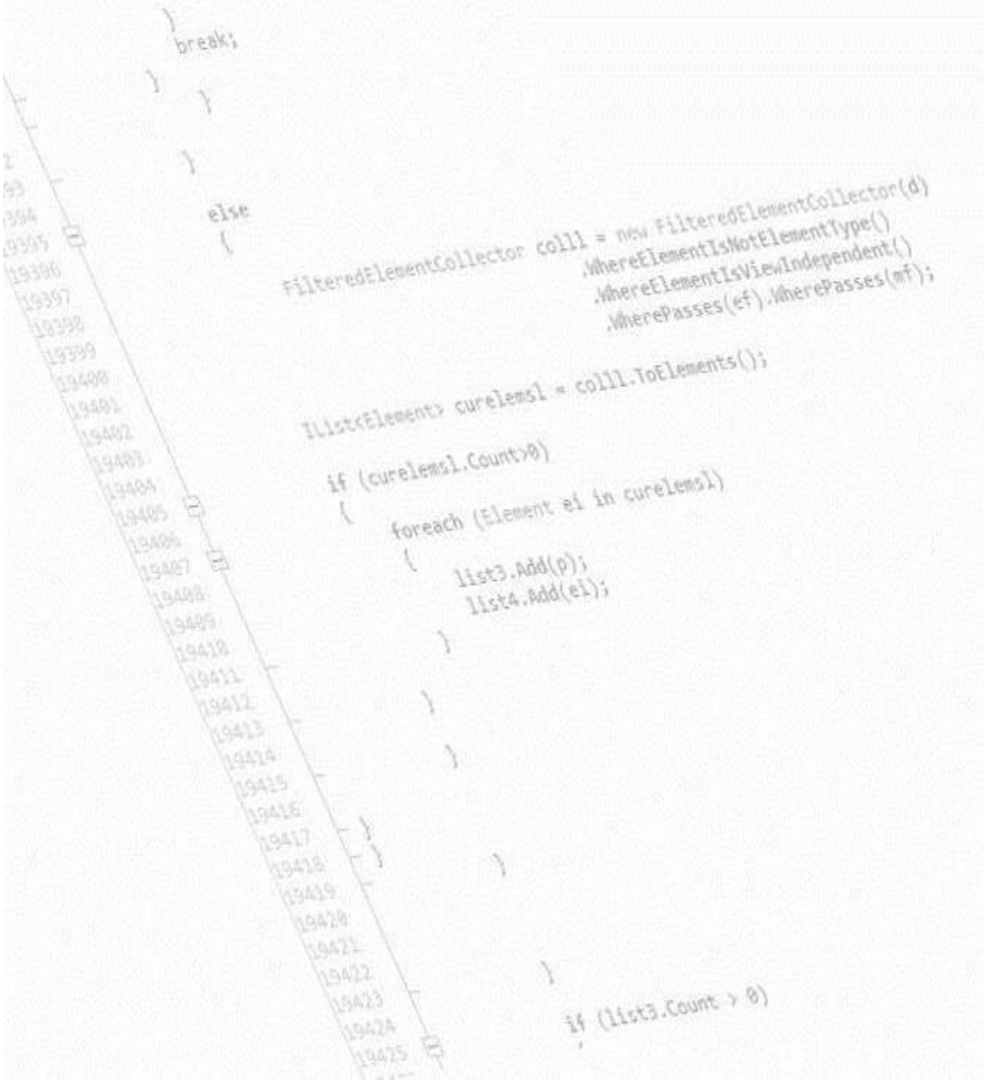
API: APPLICATION PROGRAMMING INTERFACE

Because no matter what software developers do, there will still be room for automation…

- Made available by software publishers to users and developers.
- Allows software users to integrate new workflows into the software without exposing/editing the software's source code.
- Ex: Excel VBA macros, AutoCAD LISP scripts, REST API…

REVIT IS NO EXCEPTION

- Public Revit API available since Revit 2009
- .NET Framework Based API
- Conventionally accessible through DLL referencing within a .NET Class Visual Studio (or SharpDevelop) project.
- Common forms of automations made available: add-ons, macros…
- … and Dynamo scripts.

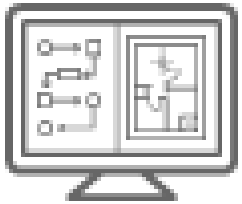


DYNAMO: FROM A VISUAL PROGRAMMING SOLUTION TO A BUZZWORD

WHY DYNAMO?

VISUAL PROGRAMMING WITHIN REVIT

- Knowledge in a .NET language required: VB.NET, F#... But mainly **C#**
- Industry of architects, draftspeople, and engineers=> **C#** felt like gibberish to most.



- Visual Programming emerging within the automation world. Ex: Game Engines
- Lower learning curve
- Fits a geometry driven industry well

- Dynamo = Visual Programming Revit **Add-in**
- Conceived by Ian Keough (a.k.a Father of Dynamo)
- Maintained and updated by Autodesk

WHY IS DYNAMO GREAT?

IT'S EASY TO LEARN AND USE

- Common functionalities are packed inside nodes
- Users just have to connect them in order
- Anyone can use it.
- Even for developers: faster prototyping
- Great community

IT SAVES YOU TIME

- Eliminates repetitive tasks.
- Saves your company time=> money.
- Users become more focused on important tasks.
- You become an internal superhero

IT CAN DO A LOT

- Generative Design
- Automated model clean-up
- Automated Q/A
- Automated submittals
- Automated Coffee
- Automated Emails
- Super Mario Bros. Emulation

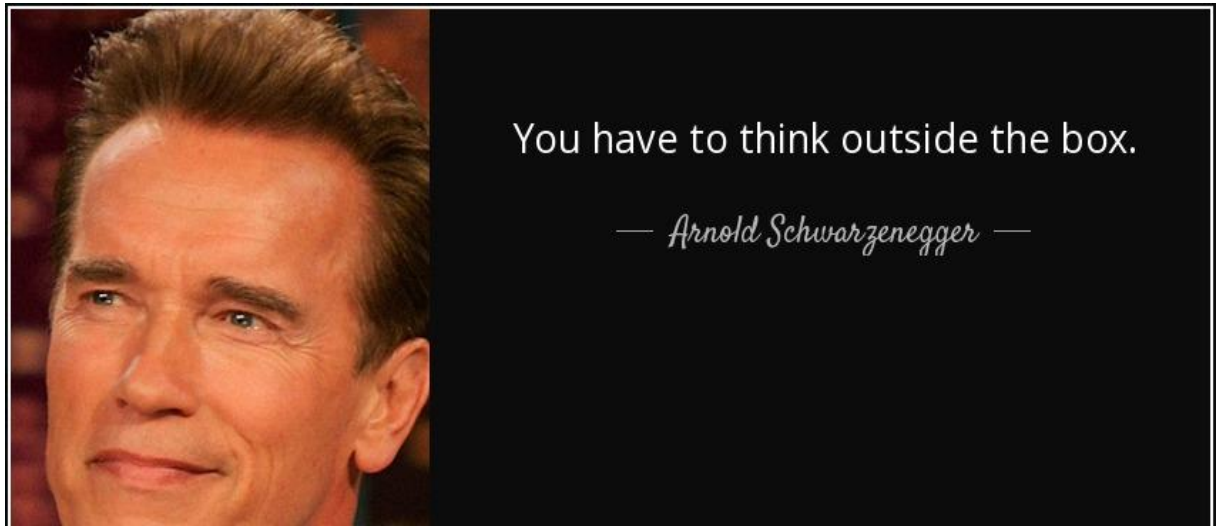

There’s always a
HOWEVER

By becoming a buzzword, Dynamo has created an illusion that it’s the only automation technology solution for the AEC industry

Dynamo has many API functionality and performance limitations

Many alternative automation methods and Forge cloud APIs are not featured within Dynamo

LET’S GO **BEYOND DYNAMO** AND FIND OUT MORE!



BEYOND DYNAMO – PART I: ADVANCED REVIT API WORKFLOWS

VISUAL PROGRAMMING THROUGHOUT HISTORY

- 1954, FORTRAN: First programming language with a functional implementation
- 1970: Pygmalion & GRaIL

LANGUAGES THROUGHOUT HISTORY

- 4000 BC: Logographic languages ex: Egyptian Hieroglyphs
- 1050 BC: First known alphabet: Phoenician Alphabet

= BIRD TOOLS?

OPPOSED DIRECTION OF EVOLUTION!

VISUAL PROGRAMMING: PROS AND CONS

VISUAL PROGRAMMING

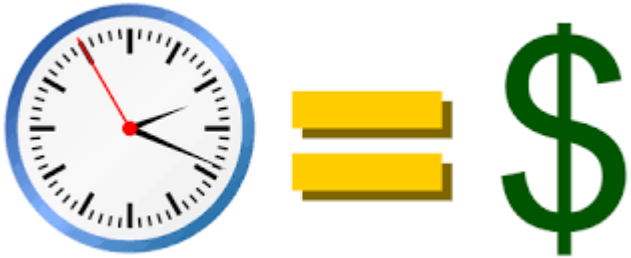
- Pro: Easy to learn
- Con: Less Control
- Con: Less optimization=> Slower execution
- Con: Functionalities limited to the available nodes

CONVENTIONAL PROGRAMMING

- Con: Harder to learn
- Pro: Low level control
- Pro: Code can be optimized for better performance
- Pro: Full access to the libraries

“Old School Revit API”
Advantage 1: (Significantly) Better Performance

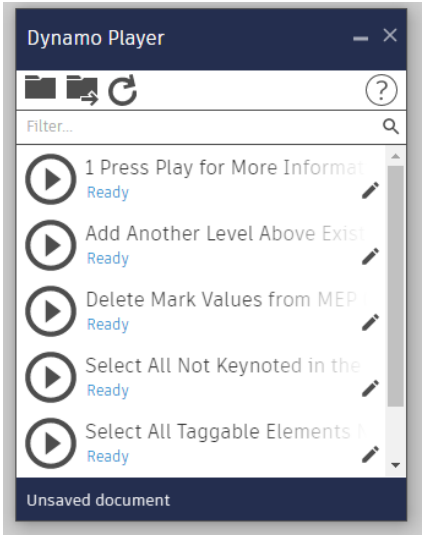
- Low level control over the entire process
- Ability to reduce commit operations
- Ability to reduce the number of iterations and eliminate common node operations
- Direct access to the libraries=> better performance
- Real-case Scenario: Viewport generation Dynamo script: 18 minute execution time
- Equivalent converted add-in: **45 second** execution time!



“Old School Revit API”
Advantage 2: Better and Friendly User Interfaces

Dynamo (Out Of The Box)

- Execution within Dynamo or Dynamo Player: scripts harder to access
- Limited functionality or no UI forms

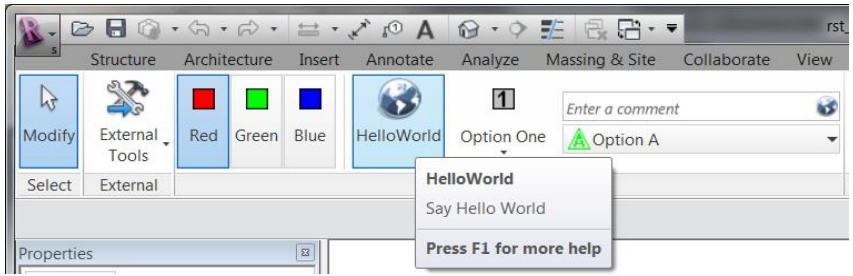


Add-ins

- Ability to create ribbon pushbuttons: Easy Access + support for **Keyboard Shortcuts**

Add-ins/Macros:

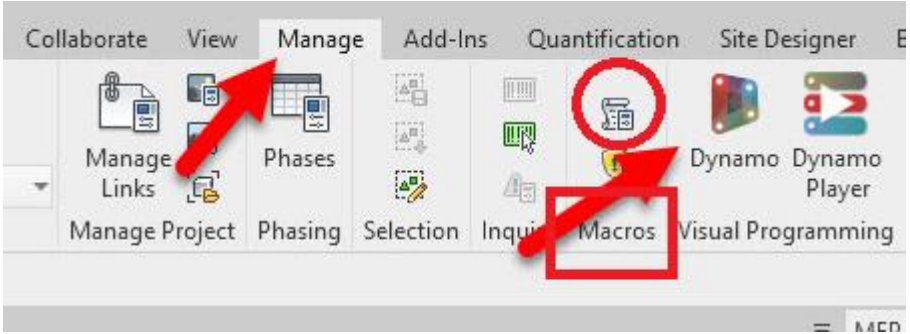
- Highly Flexible User interfaces: windows forms, interactive modeless forms, **panels and palettes**



“Old School Revit API” Advantage 3: Deployment and Embedding

Dynamo Scripts (Out Of The Box)

- .dyn files => require manual referencing on every workstation



Add-ins

- Installers can batch deploy the solution company wide => less time spent, and less risk of deployment failure

Macros

- Can be accessed right next to Dynamo’s button (Macro button colorless and way smaller)
- Can be written in C#, VB.NET, (Iron)Python, and Ruby (2021-)
- **Can be embedded within a Revit model**

“Old School Revit API” Advantage 4: Revit Event Control

- Not supported by Dynamo (or if supported through a Python script, not automatically registered at startup)
- Allows the execution of an automated Revit functionality at certain events

“Events” in this context doesn’t mean “rock concerts”!

Examples include:

element placement, element modification, element deletion, document opening, closing, saving, synchronizing with central, Revit application instance opening, exiting, idling…

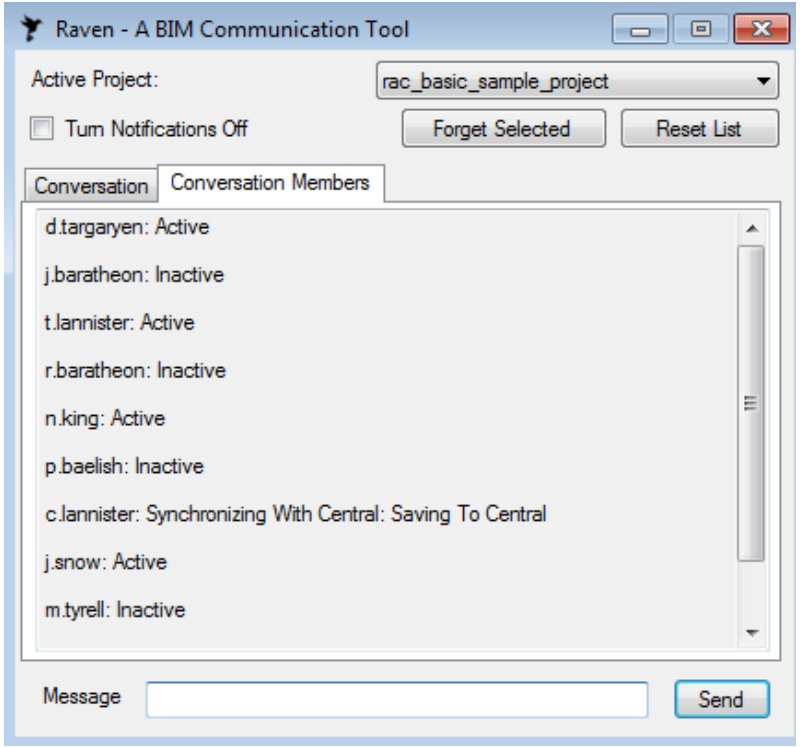
Potential Applications

Document macro that sets worksets based on usernames when a document is opened, monitoring user idle time, auto-save, have Revit mining cryptocurrencies while at lunchbreak…

“Old School Revit API” Advantage 4: Revit Event Control

Real-Case Application 1: BIM Collaborate Pro (BIM 360) Workshare Monitoring

- Problem: Worksharing Monitor doesn’t support BIM 360
- Solution: send notification to users on worksharing events (Synchronize, reload, document opening…)
- Can post notifications inside Zoom, Microsoft Teams, Slack…
- Autodesk App Store App: **Raven**

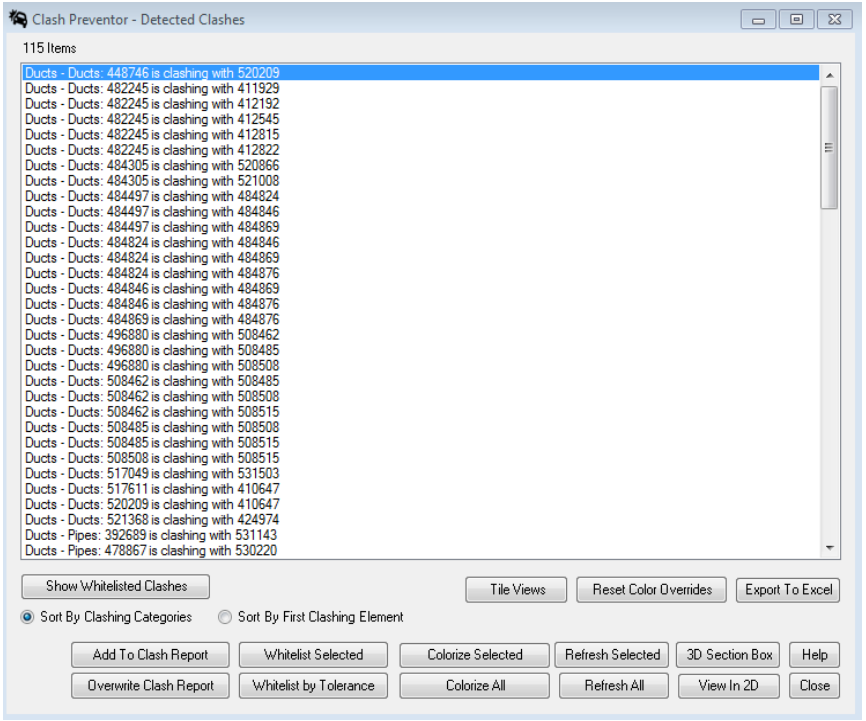


More Information: https://www.birdtools-developers.com/raven.html

“Old School Revit API” Advantage 4: Revit Event Control

Real-Case Application 2: Real-Time Clash Detection

- Detecting clashes **as soon as they occur**, whenever the document is changed or an element is added
- Autodesk App Store App: **Clash Preventor**

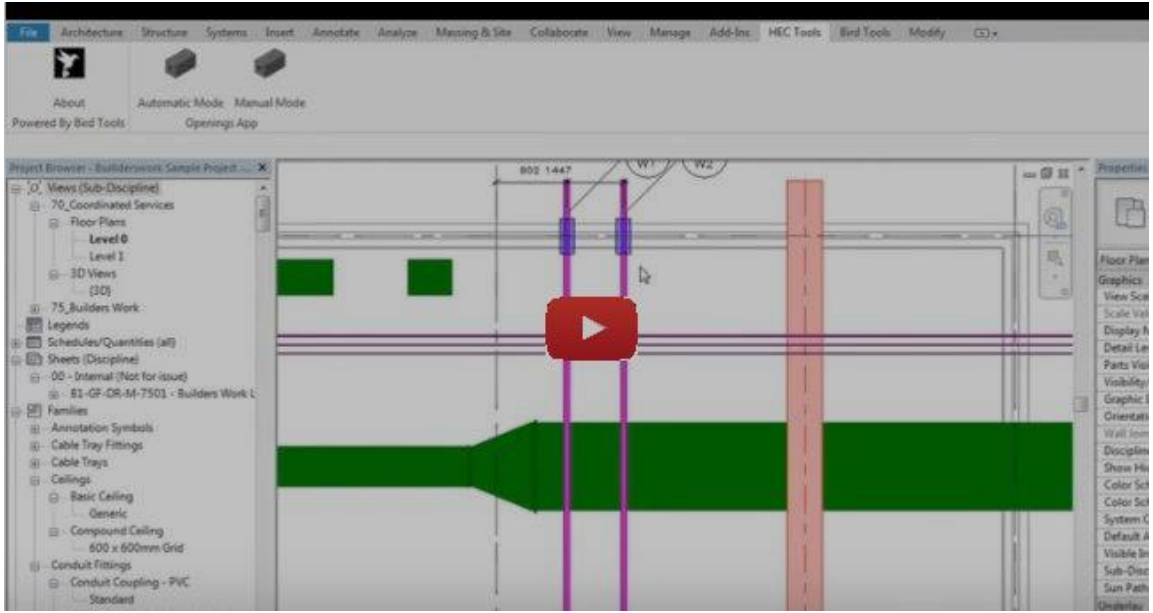


More Information: https://www.birdtools-developers.com/cprev.html

“Old School Revit API” Advantage 4: Revit Event Control

Real-Case Application 3: Dynamic MEP Hanger/Opening Placement

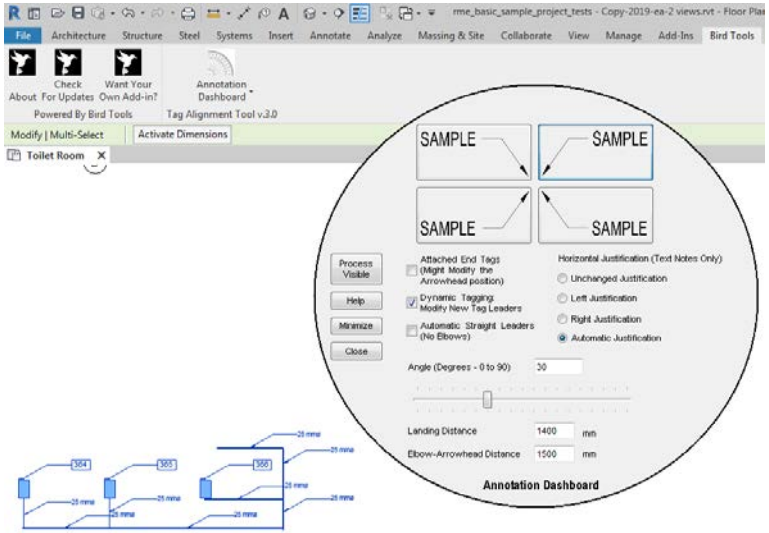
- Dynamically adding hangers and openings whenever an MEP element is modified or added.
- Ability to control categories involved through Dynamic Updaters



“Old School Revit API” Advantage 4: Revit Event Control

Real-Case Application 4: Tag properties set on placement

- Have tag leader properties automatically set as soon as a tag is placed
- Modeless customizable dashboard to control leader properties
- Autodesk App Store App: **Bird Tools’ Tag Alignment Tool**



More Information: https://www.birdtools-developers.com/tagalign.html


There’s always a
HOWEVER

“Old School Revit API”
THIS IS 2021 AND NOT 2009!!

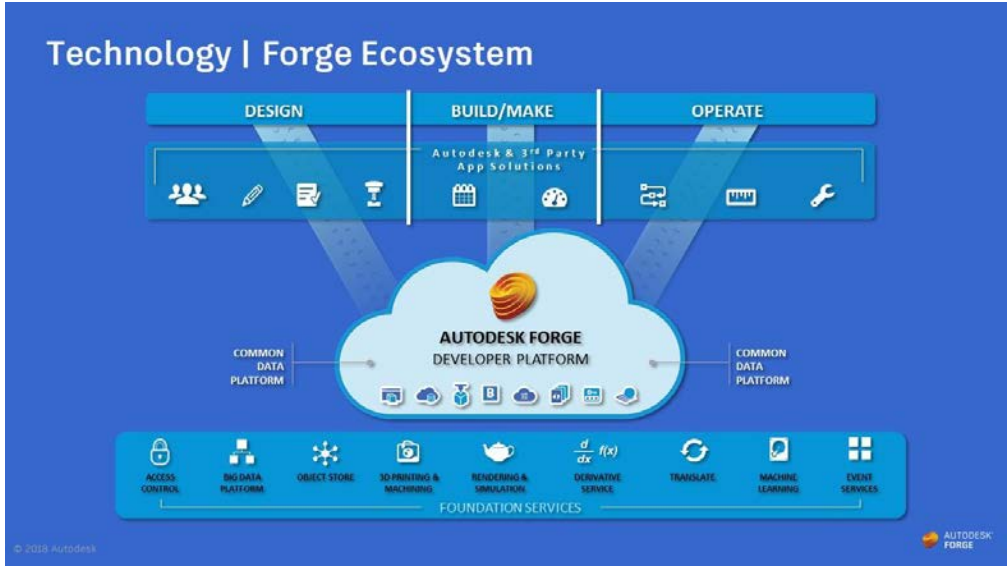
- People are working remotely
- Everything is cloud based
- Users collaborate over the Autodesk Construction Cloud and BIM Collaborate Pro
- Necessity to automate cloud operations and processes
- Neither Dynamo nor the Revit API are the solution for that
- **FORGE** is!

AUTODESK®
FORGE

BEYOND DYNAMO-PART II: FORGE

What Is Forge?

- A cloud-based developer platform by Autodesk.
- Purpose: automate cloud related operation and create new cloud systems.
- BIM Collaborate Pro, Autodesk Docs, Autodesk Viewer, Autodesk Construction Cloud => All built **on top of** Forge.
- Same Forge APIs that were used to build the aforementioned services are made public=> build your own system.
- Many APIs: BIM 360 API, Data Management API, Model Derivative API, Viewer, Webhooks, Reality Capture API, Design Automation API

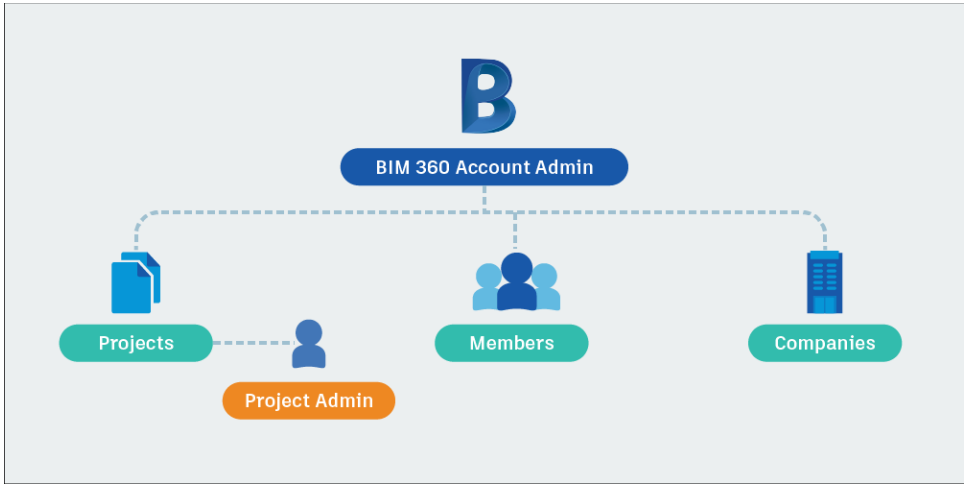


BIM 360 API

- Integrates within BIM Collaborate Pro (formerly known as BIM 360)
- API that exposes operations related to BIM 360
- Allows the automation of BIM 360 related tasks

Functionalities Exposed

- Company/Project Creation
- Permission Assignment
- Service Activation
- Cost Management
- Issue Management/Creation
- PDF Export from BIM 360
- Model Coordination Clash Results
- Relationship creation/retrieval
- RFI access

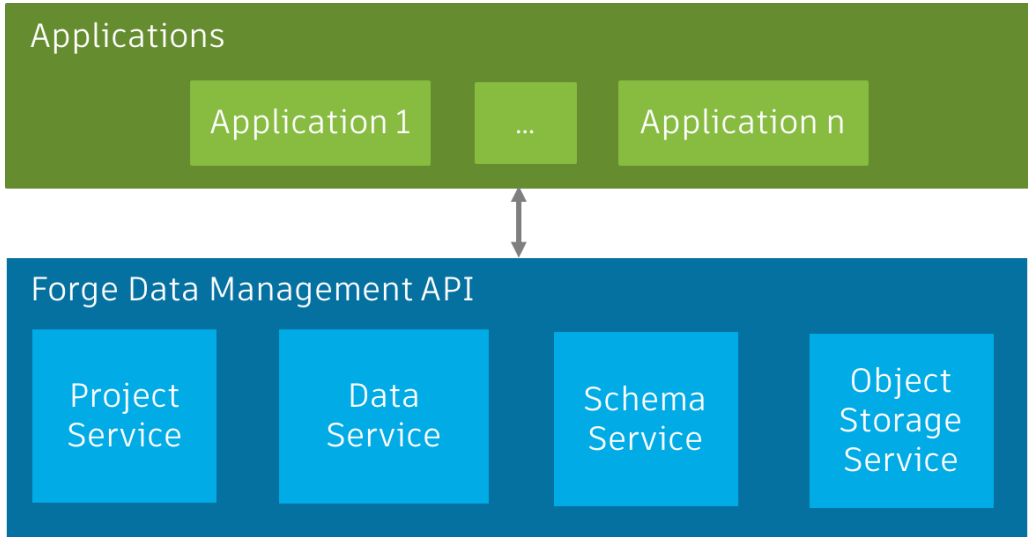


Data Management API

- Enables the query and automation of could hosting transfer operations.
- Automates Autodesk Docs operations

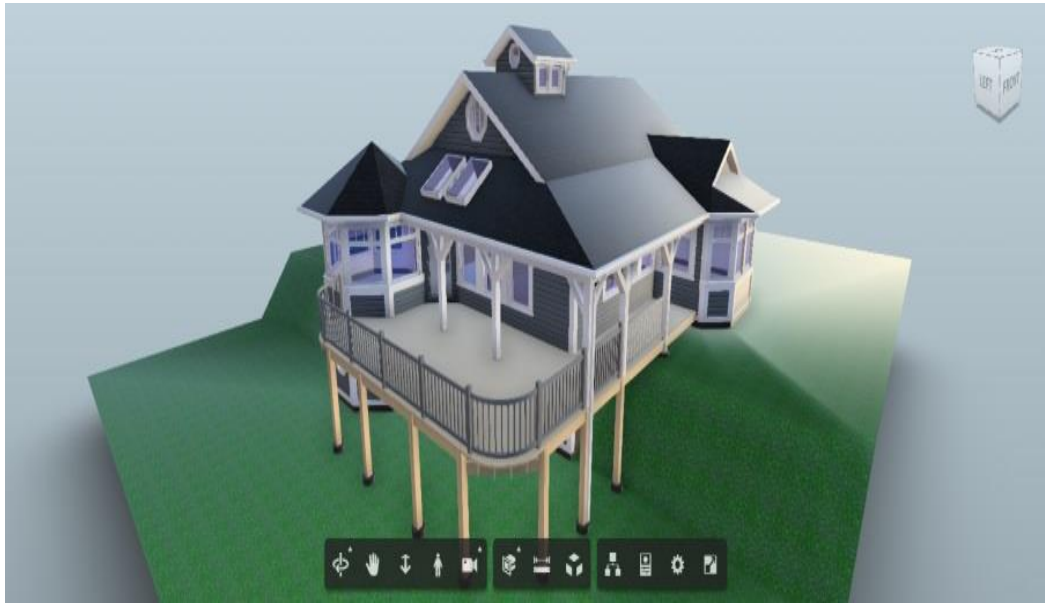
Functionalities Exposed

- File Download
- File Upload
- Attachments
- Cloud model publishing
- File Deletion
- File Restore



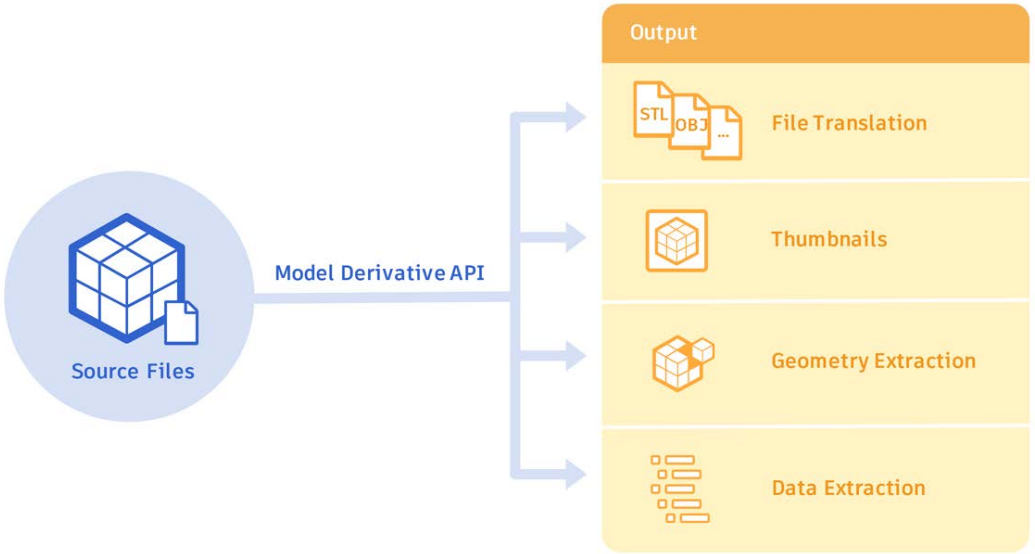
Viewer

- 2D/3D rendering library
- JavaScript library (Three.js)
- Viewer can be embedded in any web page
- Supported by several popular web browsers
- Allows Revit, AutoCAD, Fusion 360… to be navigated within a web browser and on any platform
- Features an IoT Toolkit: visualize IoT sensor data as sprites, heatmaps, timelines…



Model Derivative API

- Allows model translation into other formats, such as SVF, OBJ, SAT…
- Useful when translating models for Forge Viewer
- Allows data extraction from uploaded models: materials, density, volume…
- Allows geometry extraction from source files
- Allows extracting room, space…information

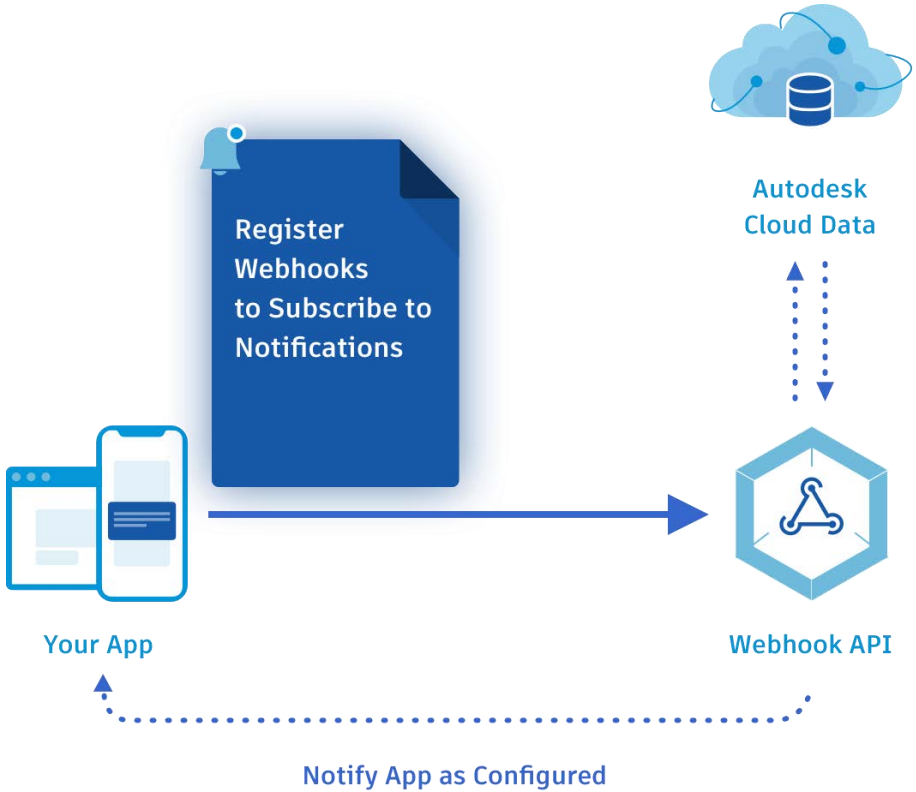


Webhooks

- Allows users to monitor events related to cloud application.
- Can be integrated with custom developed apps or back end servers
- Can also be integrated with Zoom, Microsoft Teams, Slack… incoming webhooks

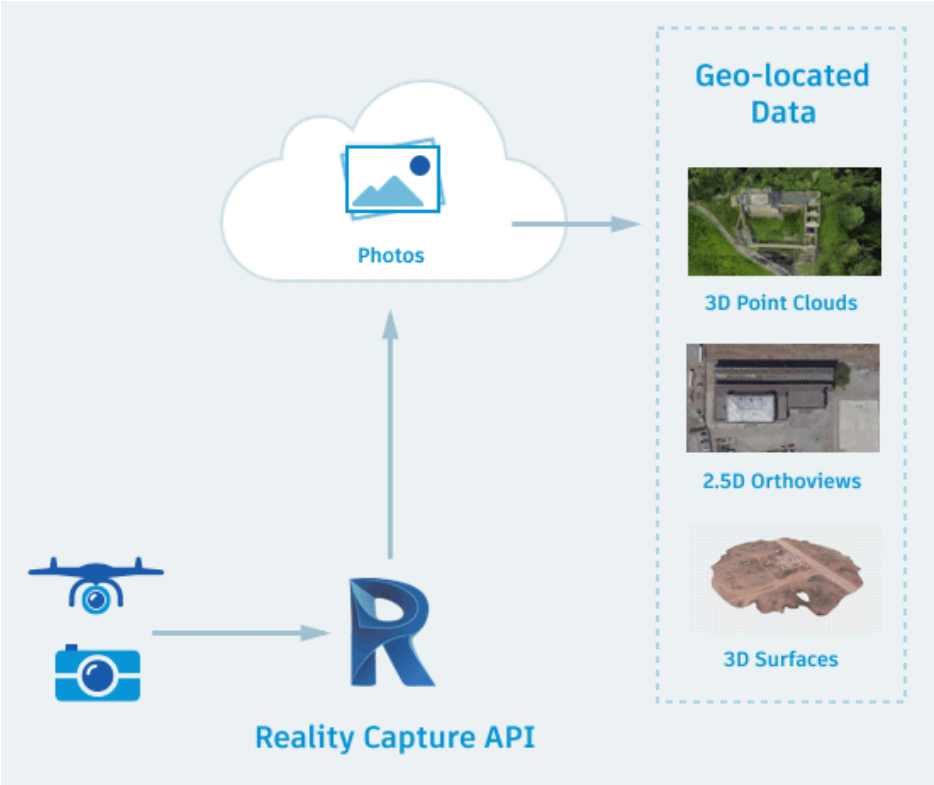
Available Cloud Events

- File Creation/Modification/Deletion
- Folder Creation/Modification/Deletion
- Model Modification/Synchronization
- Model Publish Operations
- Version Modification



Reality Capture API

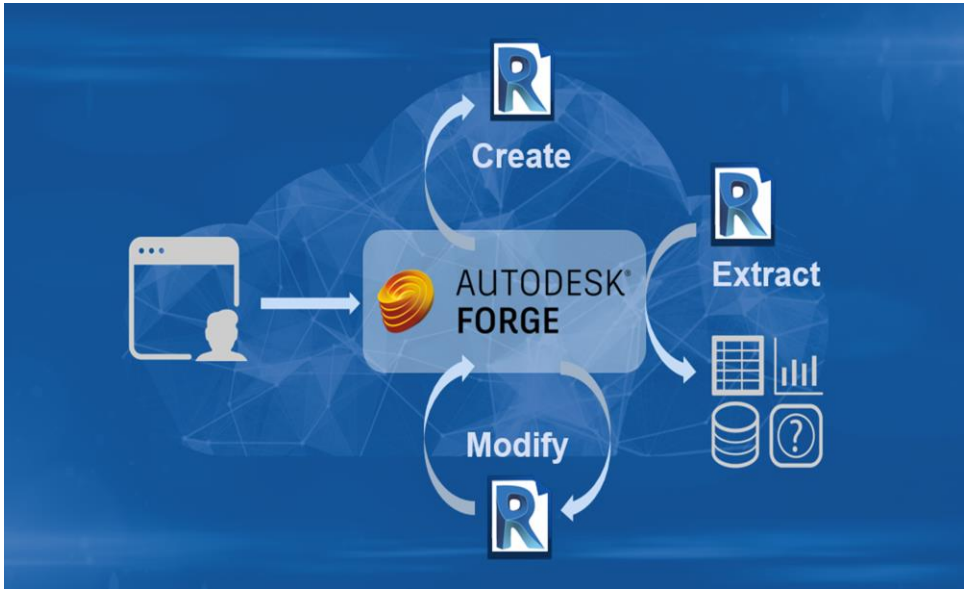
- Processes digital images into Reality Capture data.
- Generates meshes from digital images.
- Generates dense point clouds from digital images
- Ideal to convert aerial images into 3D topography for example



Design Automation API

- Simply put: Runs Autodesk Software instances and executes scripts and add-ins in the cloud and over cloud models.
- Supported Platforms: AutoCAD, Revit, 3DS Max, Inventor.
- Provides additional virtual workstation in case everyone available in place is in use.
- Offers an increased performance compared with desktop solutions.
- Lower execution times.
- Is accessible from any Desktop or mobile platform or web browser.

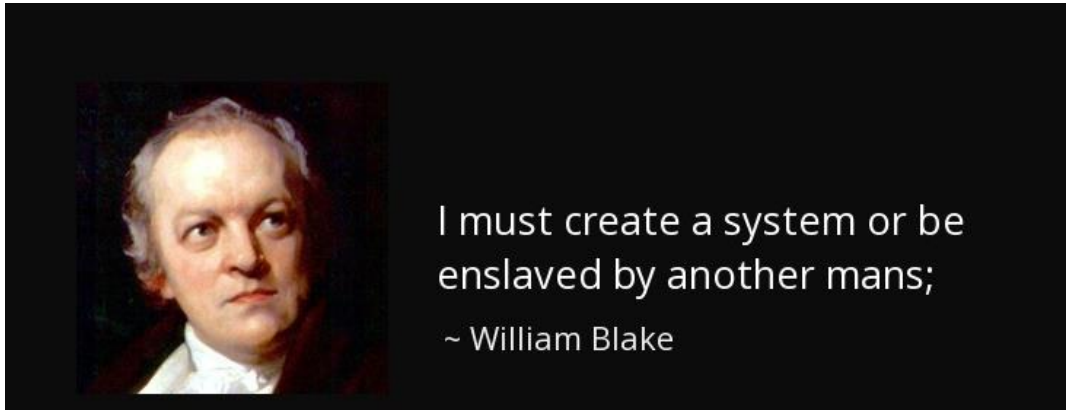
P.S: More details and step by step guides about each API can be found in the Class Handout.




“JUST WASN’T ENOUGH TIME, MICHAEL”

Applications

- BIM 360 integrated solutions: automating BIM 360 operations such as project creation and permission assignment
- Automatic Cloud Data Backup applications
- Customized web based viewers
- BIM 360 activity monitoring
- Remote cloud model processing: perform automated operation over cloud models remotely without opening them
- Customized Common Data Environments
- Customized Digital Twin platforms
- Integration of IoT monitoring over the cloud



Project Dasher and the MX3D Bridge

- Located in Amsterdam
- Robotically 3D Printed
- Smart Bridge: Equipped with monitoring sensors
- Sensors cloud connected to form a cloud hosted digital twin
- Monitoring solution: **Project Dasher**
- Platform used to develop Dasher: **FORGE**
- Live sensor data can be publicly accessed through the embedded Dasher interface at https://www.smartbridgeamsterdam.com/

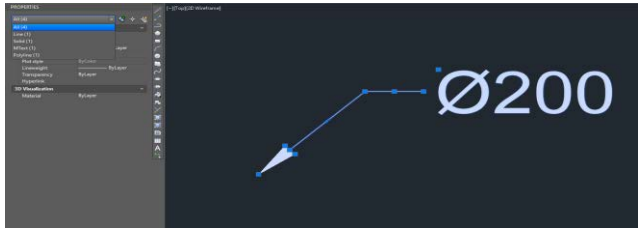
A REAL-CASE FROM AU2020: EMDC GROUP'S FORGE INTEGRATION SUCCESS STORY

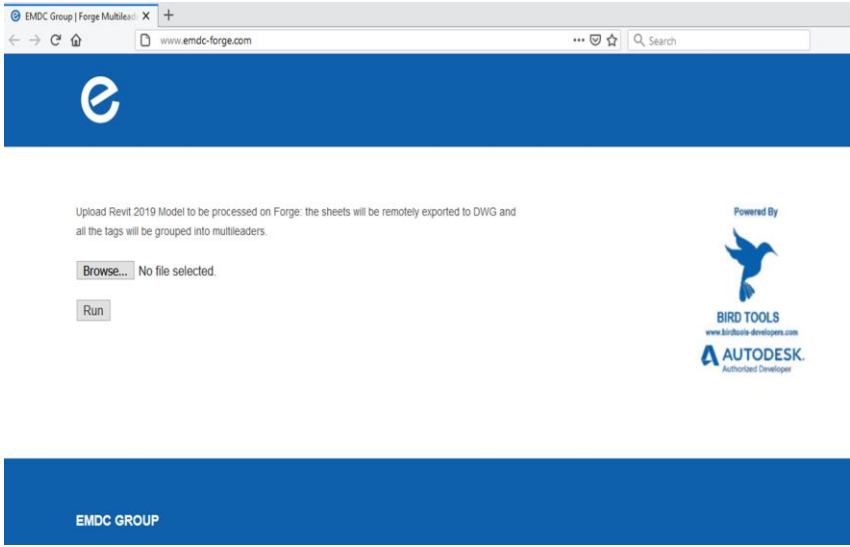
EMDC GROUP

- Leading Design and consultancy company in the MENA region
- Renowned for time efficiency and quality of submittals
- EMDC Group's secret recipe: experience, hard work, teamwork…but most importantly, a management that embraces **innovation** and **automation**
- Long history of automation integration: from the old LISP days to the upcoming Forge and AI ones
- AU2020: Class featuring EMDC Group's Forge automation

FROM AU2020
REAL-CASE APP 1: FORGE MULTILEADER GROUPING

- DWG submittal required of Revit sheets based on specific standards, including multi-leader tags
- Default DWG Export: Exploded Tags
- Solution: Using Machine Learning (Clustering) to group and combine tag components
- Interoperability process through **Forge Design Automation for Revit and AutoCAD**
- Why Forge: way faster execution time and universally accessible web interface





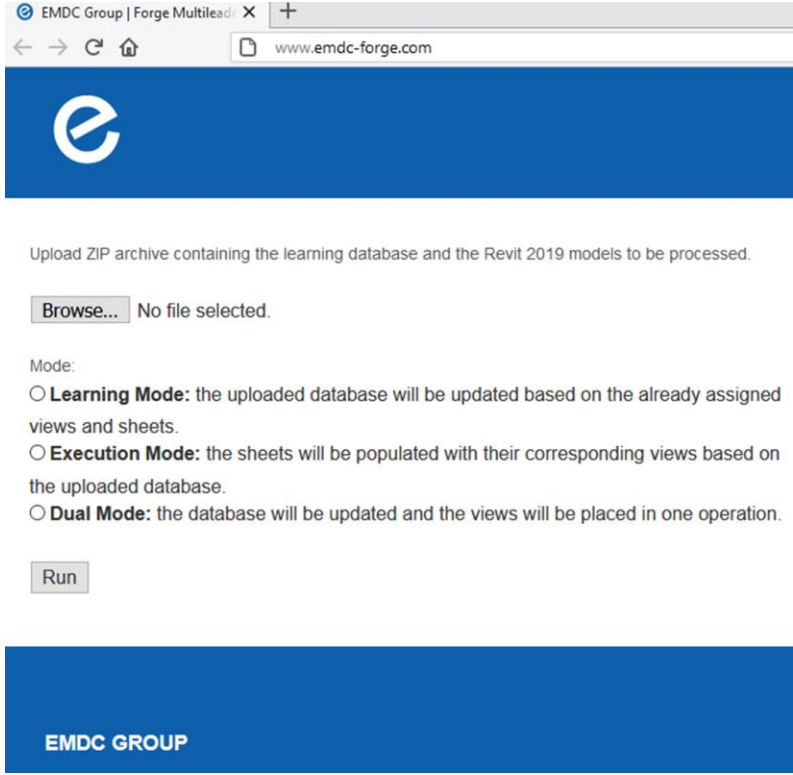
Reference: AU2020 Class [Combining Forge and Machine Learning to Automate Time-Consuming Tasks]

FROM AU2020
REAL-CASE APP 2: FUZZY LOGIC REVIT VIEW PLACEMENT

- Using machine learning to automate view placement on sheets
- Using **Forge Design Automation for Revit** to process the learning database

Why Forge

- Multiple models packaged, uploaded and processed at once.
- Cloud computing solution that executes remotely and autonomously.
- More available resources and universally accessible web interface



Reference: AU2020 Class Combining Forge and Machine Learning to Automate Time-Consuming Tasks

Stats & Figures Implied by Forge Integration

As measured at EMDC Group

35

PROJECTS/YEAR

ON AVERAGE ARE EXECUTED BY EMDC GROUP

2775

HOURS/PROJECT

ON AVERAGE ARE REQUIRED WHEN ESTIMATED WITH A FULL MANUAL EXECUTION IN MIND

1250

HOURS/PROJECT

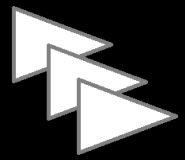
REQUIRED, COMBINING ALL CUSTOM BUILT AUTOMATION ADD-ONS AND FORGE SOLUTIONS

53375

HOURS/YEAR

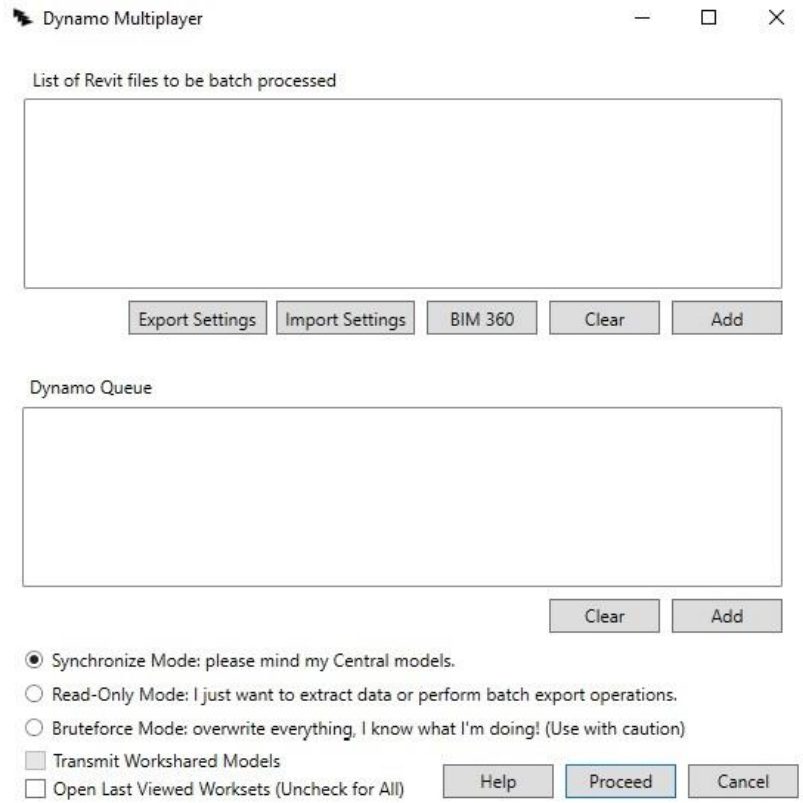
OF WASTED TIME ELIMINATED AND USED TO HANDLE MORE WORK

BONUS EXAMPLE: DYNAMO MULTIPLAYER



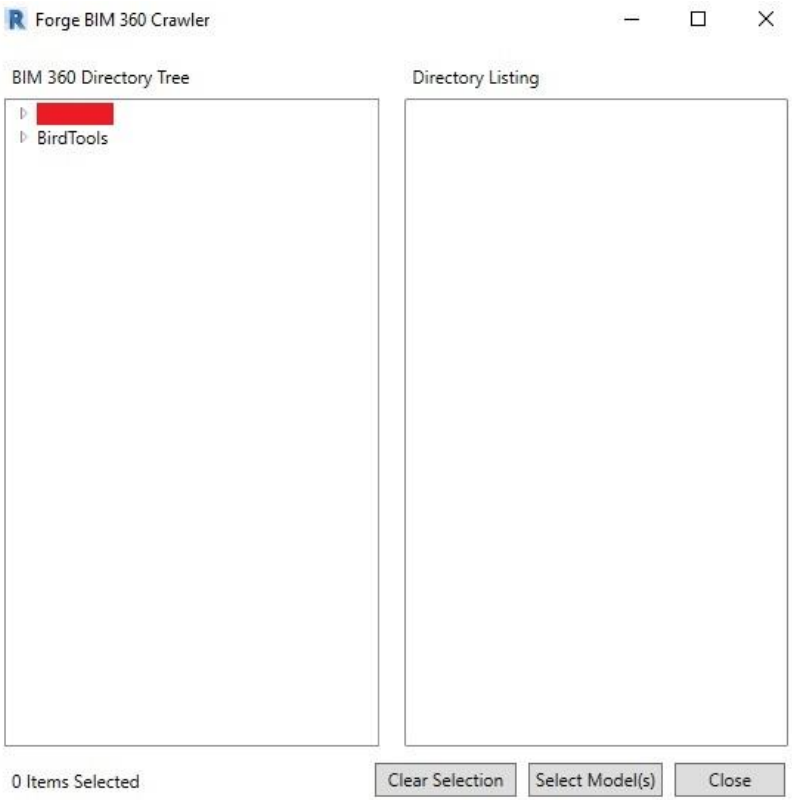
DYNAMO MULTIPLAYER – A FREE REVIT BATCH PROCESSOR

- Uses the Revit API to batch open and save Revit files
- Uses the Dynamo API to process files on an individual level=>Universal Batch Processing Tool that can do anything.
- Opening locally stored files: straightforward and conventional
- Opening BIM 360 models: not possible conventionally=> **using Forge to retrieve the cloud paths**



DYNAMO MULTIPLAYER – FORGE APIs INVOLVED

- Forge Data Management API: retrieves hubs, directories and models
- BIM 360 API: retrieves accessible BIM 360 projects
- Dedicated BIM 360 model directory and file browser: retrieves BIM 360 cloud paths using Forge
- **Forge + Revit API = BIM 360 automation within Revit**
- Potential applications: batch initiate to BIM 360 – batch reload BIM 360 links – batch open BIM 360 models…



More Information: https://www.birdtools-developers.com/dmu.html

LET’S SUM IT UP!

EMBRACE ALL FORMS OF AUTOMATION!

KEEP IN MIND THAT:

Dynamo is easy to use and great, BUT:

- Visual Programming limits possibilities and efficiency.
- Many API aspects are still not covered out of the box.
- Cloud Operations can also be automated.

- **Forge** is not the future: **It Is Here. Embrace it today, or you're left behind!**

EARLY NEW YEAR'S RESOLUTION FOR 2022 BASED ON AU 2021

In Short: Start Embracing Automation

- If you haven't already, start with Dynamo, it's great and easy
- Expand it later on with Python or .NET macros.
- Dive deep into the Revit API and start building add-ins based on your Dynamo prototypes.
- Start investigating and integrating all **Forge** APIs, again, **you'll be left behind if you don't!**
- If you don't have time for all that, find an expert to do it for you (Autodesk Authorized Developer or Forge Integrator).

“You’re either the one that creates the automation or you’re getting automated.”

Tom Preston-Werner

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