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Building Massively Scalable CAD Configurators for the Manufacturing Industry

Nem Kumar
Centre for Computational Technologies Private Limited, India

Subhransu Majhi
Centre for Computational Technologies Private Limited, India

Ashish Shete
Centre for Computational Technologies Private Limited, India

Learning Objectives

- Learn the basic concept of CAD configurators and the benefits
- Learn to create CAD configurators using the Forge platform
- Learn how to analyze the time and cost effectiveness of solutions built on Forge and various cloud-computing platforms.
- Select appropriate computing services from various cloud platforms.

Description

CAD software requirements are drastically changing from the traditional use of desktop-based software usually consumed by the design department. Demand for cloud-based CAD web apps (also consumed by non-technical executives) is increasing. In the class, we will see how the Forge platform and various cloud infra providers can be utilized together to create modern-day vertical CAD configurators as per the specific need of each organization. Based on stats and test cases, we will demonstrate how a serverless CAD configurator can scale up massively to address the peak-hour needs of industry while staying low on budget. We will explain how Forge services can help us to bootstrap our applications and reduce the development time to as few as just three months and bring down the development cost substantially.

Speaker(s)

Nem Kumar

He is director of consulting at CCTech and has been doing product development with companies from Manufacturing, Oil & Gas and AEC domain. He has vast experience in Desktop as well as Cloud software development involving CAD, CAM, complex visualization, mathematics, and geometric algorithms. He has been actively working with Autodesk Vertical, Research and Fusion 360 teams. His current areas of interest are Generative Modeling and Machine Learning

Subhransu Majhi

Subhransu leads a research team at CCTech that develop AI-powered solutions. He has been working with CCTech for more than 7 years. He is a mechanical engineer and has worked with teams that have developed software for various domains like CFD, Computational Geometry, Genetic Algorithm, Artificial Intelligence, Augmented Reality.

Ashish Shete

Ashish is a software development manager at CCTech. He has been working in the CAD development field for more than 12 years. Ashish has a master's degree in Automotive engineering. He has been part of teams that have developed CAD and PLM applications for maritime, oilfield, and manufacturing domains. Ashish's areas of interest are visualization, computational geometry, web-based 3D applications and automated testing.

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Need for product configurator

This industry talk provides a high-level architecture of building web-based CAD configurators using the Forge platform and industry's leading cloud providers like Amazon and Azure. This handout would provide insights into different cloud services and strategies which can be used to build a massively scalable configurator. Although the focus would be on scalability, various essential cloud services like authentication, security, etc. would also be discussed.

CAD configurators have been there in the industry since CAD software vendors started to provide Macro recording and provide APIs for customization. Exposing low-level functionalities through various programming interfaces helped companies build configurable products that helped them get a competitive advantage, as it helped them in

- reducing lead times,
- automating quotation documentation,
- increasing workforce efficiency,
- eliminating errors and rework
- increasing customer satisfaction.

Though these product configurators enjoyed a lot of attention at the start, they lacked

- cost-efficiency as they were still tied to desktop CAD software and its licensing policies
- You still needed to carry a heavy laptop with CAD software installed to your customer for review

and there are so many things which limited its broader adoption in the company and their customers.

Thanks to recent developments in the hardware technologies and browser standards, these product configurators, and their artifacts have enabled these product configurators to graduate from the existing silos to a broader audience, be company employees or its end customers. Previously CAD data had only been accessible to the design team of the organization. Other departments of the organization like marketing, sales, and manufacturing only get one of the derivative formats of this rich CAD information. For example, the marketing team had 3D rendered videos and images, the sales team had the specifications information, while the manufacturing team mostly worked on the DWG file and the assembly team on the PDF files with illustrative instructions.
Today, we can go paperless with the help of mobile devices and visual work instructions available to the business's complete value chain.

Product configurators now are fully cloud hosted, browser-based web applications which are 24 x 7 accessible to anyone from anywhere and on any device. Further below, we would go more in-depth into building these web-based CAD configurators and learning best practices to make them massively scalable.

The rest of the industry talk below tries to develop a scalable configurator using a fable. The fable is fictional but is based on real events.

"All characters appearing in this work are fictitious. Any resemblance to real persons, living or dead, is purely coincidental."

The fable of developing a CAD Configurator

After massive storm

Joe is a sales engineer at the PAT Dynamics power division. He is in Haiti where a massive storm has flooded the only powerplant on the island. The town of Jambuti is facing a power blackout since the storm has passed over. The Powerplant is in the bad shape. It would take months before it could be made functional. But the town council wants to restore the power supply as soon as possible so that life can be back on track on the unfortunate island. PAT Dynamics has a real chance to set up their portable power plant and help the people of Jambuti. The town council has invited two more companies to evaluate the situation and provide estimates so that they can decide which company should work on this project.

The PAT Dynamics sends Joe to survey the situation and work with the council on the proposal. He visits the allocated site for the potential portable power plant. He has to create a layout of the power plant, get the estimates from his team back in the office, and get approval from the town council as soon as possible. Time is the essence. Once the approval is made, the power

equipment will be shipped to the island and can restore the power after setting up their operations.
He gets the geolocations of the boundaries of the proposed site and sends it to the back office for his colleagues. They will try to fit the equipment on the site layout based on the power supply requirements of the town.

Satellite images of the location

The back office receives the coordinates. Based on the satellite images, they create a plan and estimates in the next two days. They use Inventor to create this layout and sends back these drawings and estimates to Joe. Everything looks good, but on a closer look, Joe finds that the satellite images that they used are older. The back-office engineer had put the main power turbines in a place that has a water tank on the actual location.

Joe cannot use this plan to present to the town council. He calls back his office reporting that they will need to make changes. This takes another day until after 3 days he gets the plan in a PDF format to present to the council. By this time, one of the other companies gets approval based on their initial plan. The PAT Dynamics loses the deal.

Deal lost

Joe is disappointed. He thinks that if he had Inventor with him, he could easily create the layout himself and show the drawing PDFs to the council. He had been following with The PAT Dynamics to give him an Inventor license and a laptop powerful enough to be able to run Inventor. Also, he would need Inventor training. His boss kept on denying this request because they could not provide Inventor seat to each of the field engineer neither training essential to operate Inventor. Also, every layout needed due diligence from the home team. Long story short, Joe and his fellow field engineers will have to live with this delay.

On his way out of the island, Joe meets the sales engineer of the other power company that got the contract. Her name is Samantha. He asks her how did they create the proposal within a day. Samantha smiles and only say that she was exactly facing the same problem a few months ago.

Joe's Quest

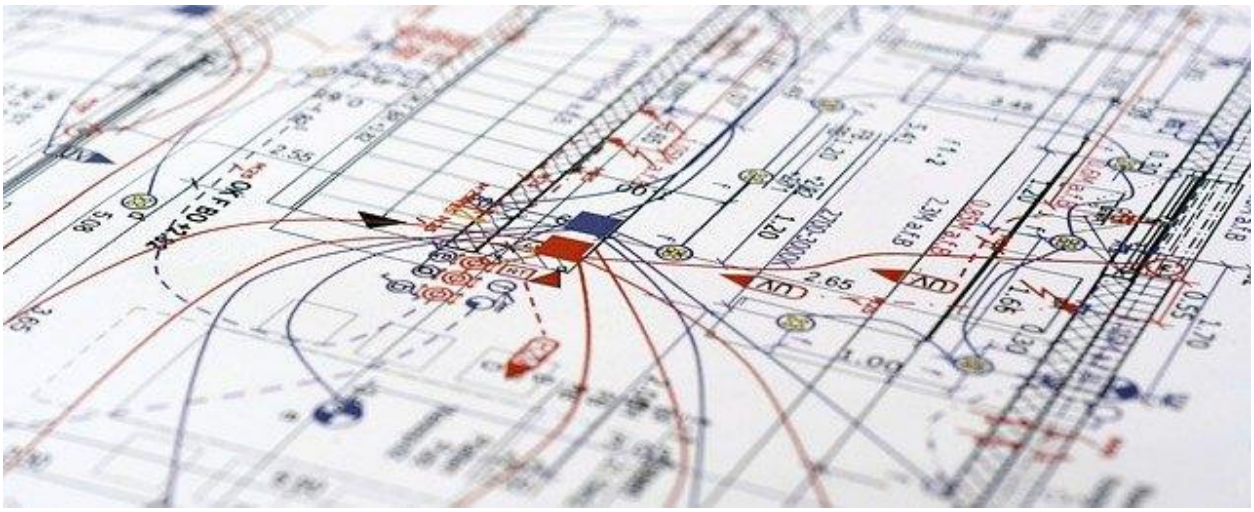
The first thing Joe plans to do when he comes back to the head office is to set a meeting with his manager. In this meeting, He has managed to convince his bosses that higher turnaround

time in situations that demanded fast operations is a business killer. Having a solution of this problem became a priority now that the big guys know that competitors have the solution, and they don't. The management have realized that if they are in a business of quick power, their initial estimates had to be quicker. The management have promised Joe to help him get the required tools which can reduce the turnaround time. Joe knows whom he should talk to gather the resources that he would need.

Layout engineer

The Layout Engineer

Joe reaches to his colleague David who works as a support to the field engineers. David is the one who had sent Joe the design proposal while he was in Haiti.



Complex layout

***David**: "Sorry man, I had no idea that the satellite imagery was that old. Still, we were as quick as it was possible. I wonder how the other company got it figured out so quickly"*
***Joe**: I know right? The competitor's field engineers must be doing it on the field. Is it possible for us to have it designed on the field?*
***David**: You mean you will design the whole layout on your laptop when you are on the site?*
***Joe**: Yes. I can send it to you for due diligence once it is done.*
***David**: It's not that simple. Along with the layout configuration, we also design the wiring and piping layout on top of it. It is done using the evolutionary algorithms which finds optimal paths through the equipment layout that we design. That algorithm runs on a 64-core machine which sits here in our office.*
***Joe**: Is there any way we can do it on the field?*
***David**: Even if you have best laptop, it will take hours for you to get it all done.*
***Joe**: So, you are saying that there is a way to do it on the field.*

Joe asks David to list the tools and resources that would be required so that he could have everything on a laptop. David reluctantly takes part in his charade partly to make it up for the Haiti goof up. "Okay, so let's assume that you have the Inventor license and a decent laptop." David started writing on the board.

These detailed discussions led to an initial specification of the product. Below you would find notes captured on the board.

Product Stage 1: Design Automation on Desktop

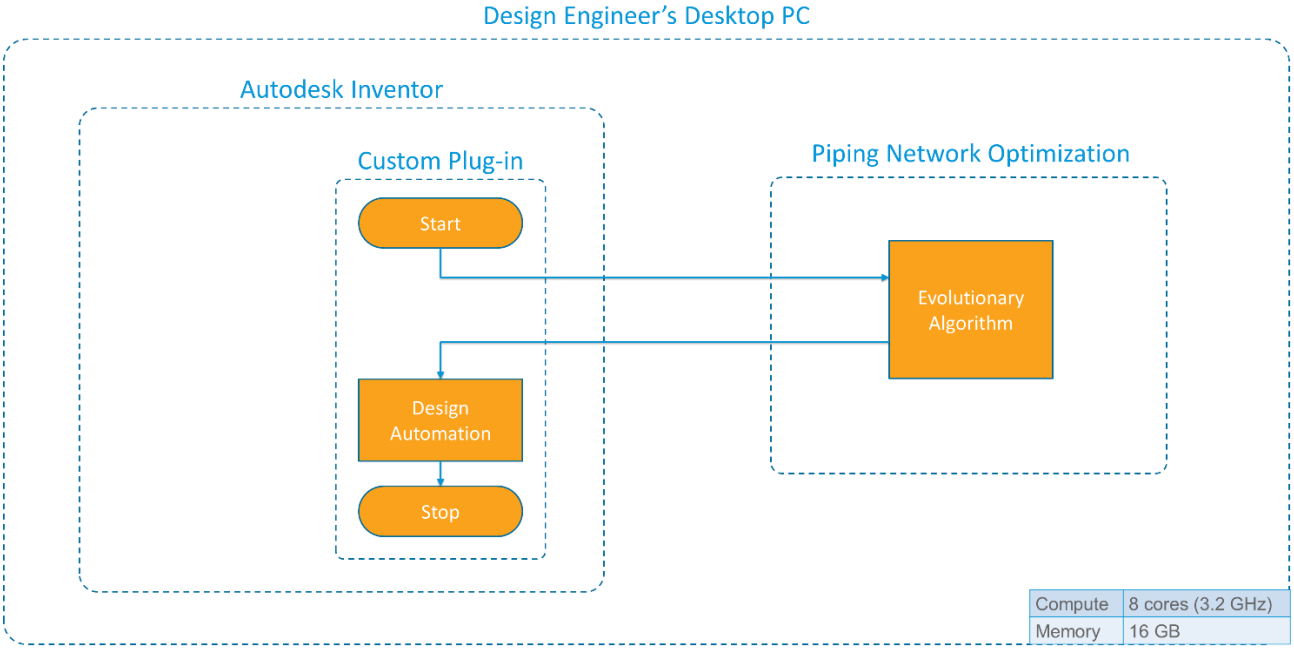
Specifications

- Need a plugin for Inventor
- Plugin provides a user interface inside Inventor for taking inputs from user
- Able to perform all design automation tasks within Inventor
- The running computer's resources are consumed for doing all computationally expensive evolutionary algorithm workloads

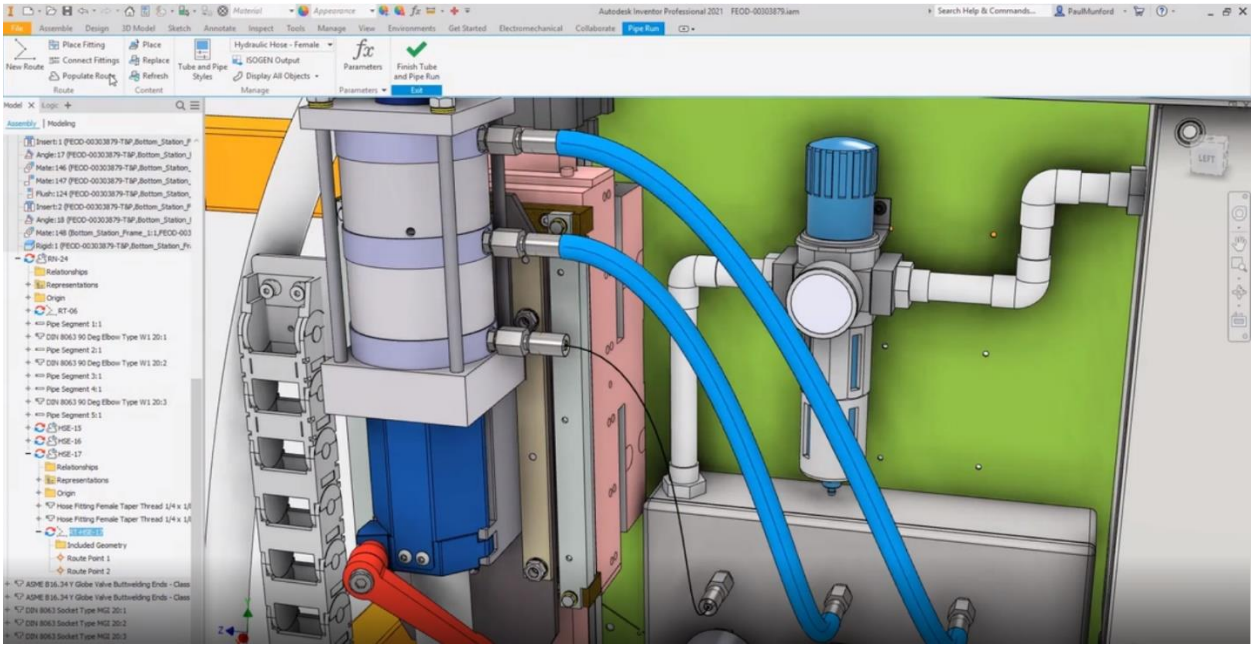
Benefits

- It would save a lot of time for all engineers involved in the process
- It would lead to reduction in errors as the whole process gets automated
- It would need very less knowledge to use the plugin compared to a CAD software

Board Diagram



Board diagram of design automation on desktop



Autodesk Inventor

Limitations

- The computer on which the plug-in will be used has to be upgraded as that it can run the non-CAD computationally expensive optimization workloads
- Optimization jobs take somewhere around 6-24 hours

What to do next!

- There is a need to run the optimization workloads on HPC machines to reduce the time consumption

These requirements lead us to the next stage of the product development

Product Stage 2: Partial movement to the Cloud

David was sure but Joe now realizes that the management would not agree to this solution as every field engineer not only will need Inventor licence but also will require a top end laptop which in best case will take hours to provide design that still will need checks from the design team. Joe asks David if he can figure out a way where the field engineers would not need a laptop which even the CEO's son does not have for playing his Grand Theft Auto – V.

"Well, first of all, unlike GTA-5 the evolutionary algorithms don't need any graphics and you wouldn't even need to interact with it once your inputs are given." David freezes for a moment. "Wait a second, there is way. We can totally run it in the cloud" says David energetically.

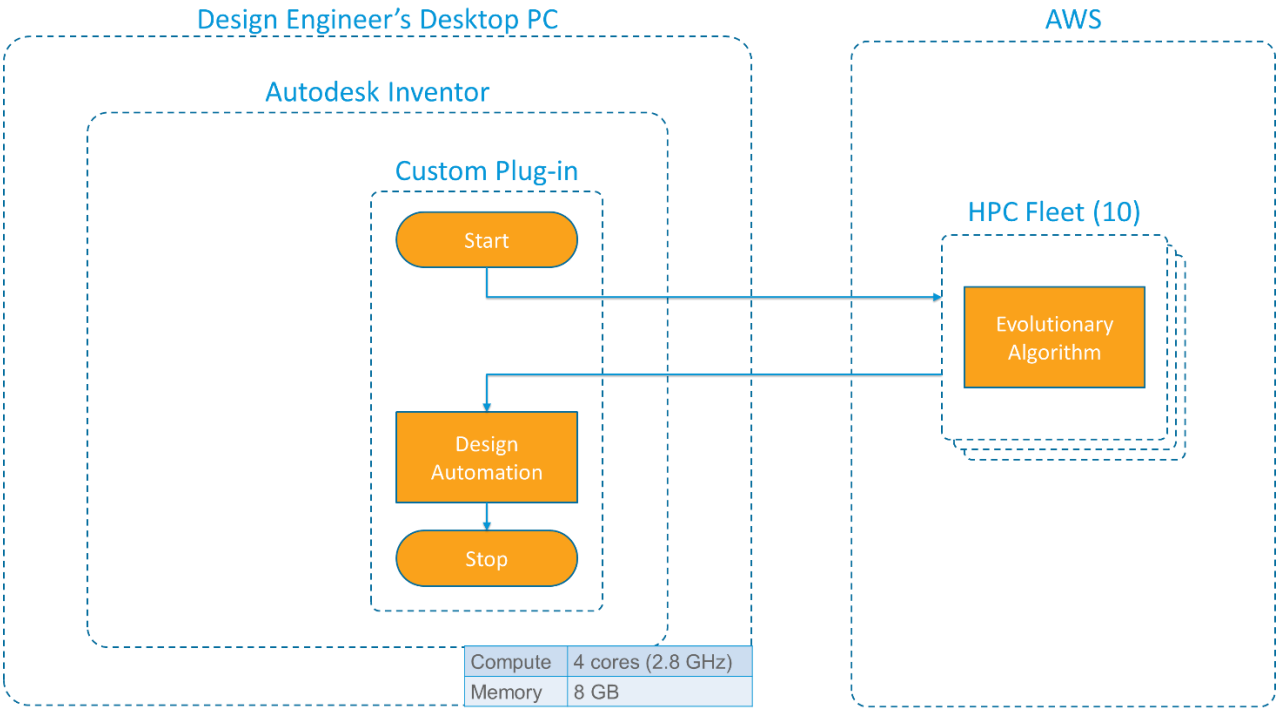
Specifications

- A fleet of 10 HPC machines is rented for performing the optimization workloads

Benefits

- Optimization jobs take between 30 mins to 2 hours

Board Diagram



Board diagram of cloud web app

Limitations

- Due to limited licenses of CAD software, only a few employees from the design department would be able to use the customized application
- Due to lack of database, data management is purely a manual process

What to do next!

- Every employee of the organization should have access to CAD configurators
- The app needs be free from CAD licensing limits.

Product Stage 3: Shift to Forge Platform

Joe is now happy. David's brain has finally stopped counting problems and started cranking solutions.

***Joe**: Now that we have solved the problem of high-end laptop, we can totally do it on my laptop isn't it?*
***David**: Well, technically yes. You will need inventor licence still. And did I tell you it will take you at least a month to get you trained on inventor? So, you will ask the management for Inventor licence plus your inventor training. Multiply that cost with the number of field engineers we have.*
***Joe**: That doesn't sound like good news to me.*
***David**: It's not. On top of it, I don't think you need to know inventor for a simple configuration job. All you need is the final drawing to present to the authorities.*
***Joe**: It seems to me that you already have a solution in your mind.*
***David**: Yes. And here it gets out of my realm. We will need a specialized application which will let you drag and drop the equipment on top of a map. I think rest can be done on the cloud.*
***Joe**: Hey wait a minute, where did the inventor go?*
***David**: May the Forge be with you.*

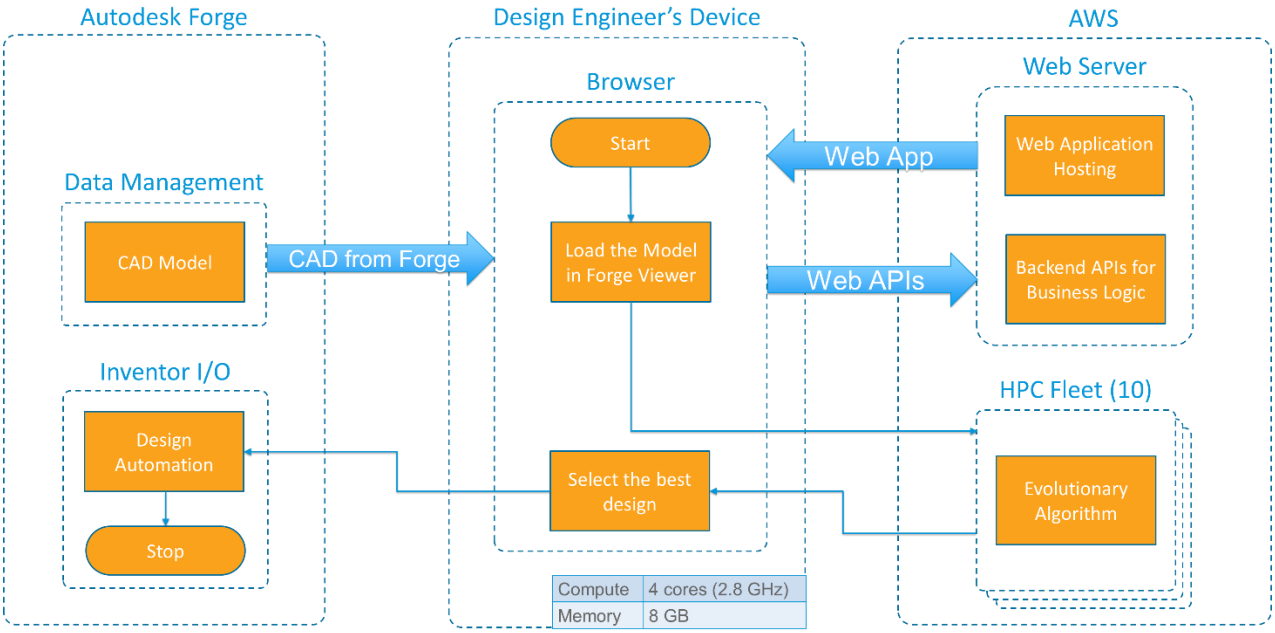
Specifications

- A server-based web application hosted in a US Datacenter
- SQL database is used for managing projects and user logins
- All CAD operations performed in Autodesk Forge cloud platform
- The application is hosted on a AWS's virtual server instance

Benefits

- All employees of the organization can access the application
- No need of CAD software license to run this application

Board Diagram



Board diagram of Shift to Forge Platform

Limitations

- Since Autodesk Forge allows as much as CAD operations to be done simultaneously and the web application is now accessible to a larger audience, the optimization jobs now get queued up on the 10 cloud HPC instances.
- At the peak hours of productivity as per office timings, the web server gets overloaded with extensive usage of the application
- Since the web server is hosted at an USA based datacenter, the web application response is good within USA. But its performance degrades from oversea office locations.
- Database backup and restore becomes a system admin's manual activity
- There is downtime whenever the server machine is being upgraded or when it crashes

What to do next!

- The web hosted system and HPC infrastructure needs to be also scalable

Product Stage 4: Massively Scalable web-based configurator

David and Joe now know that this is where they will need help of system integrators like CCTech. PAT Dynamics connects with CCTech to create this application.

In CCTech, the engineers first consider the requirements. The CCTech engineers also estimate that a scalable architecture can be introduced so that the cost of server-side computation can further be reduced. "How can we strip something which is already designed for optimization." David asks.

The CCTech engineer now starts to explain it further: "It's possible with Lambdas" the engineer says.

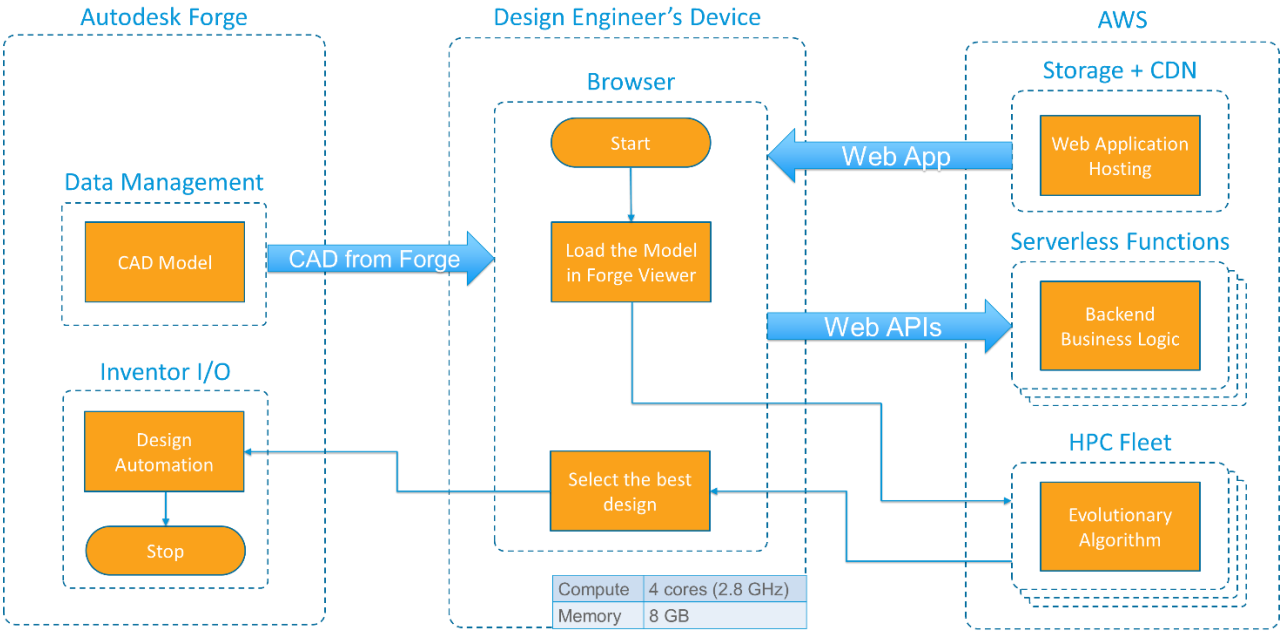
Specifications

- The front-end web application is written in a pure client-side framework
- The front-end web app is hosted on content delivery network (CDN)
- The backend APIs are hosted on scalable serverless functions
- The database used is a fully managed, scalable, and globally replicated one, i.e. no need to worry about back systems, latency, etc.
- The HPC jobs are totally scalable, i.e. no queuing at all

Benefits

- There is no need to worry about backing up database
- The web app has no latency issues when accessed from any part of the globe
- Peak loads are easily handled as scaling happens in real time
- Since, there is no server present, the system admin requirement goes away
- Due to fully serverless infrastructure, during nighttime, weekends, and holiday seasons, billing almost reduces to nothing
- Since, most of the managed services are used, the development time of web app reduced drastically

Board Diagram



Board diagram of scalable web app

What we have achieved!

- A highly accessible & scalable CAD configurator is made possible using Forge & serverless cloud services
- Running cost is extremely low as you only pay for what you consume
- Development time is drastically reduced as ready to use cloud services are integrated into the application
- Maintenance of infra is hassle free, as the application being completely serverless, it becomes the cloud provider's responsibility to look after the infrastructure

Conclusions

Building massively scalable CAD configurators are easy now with the tools and services available today. Defining your requirements carefully and choosing right and efficient cloud services would make your product configurator successful and would also enjoy wider audience and shelf life.

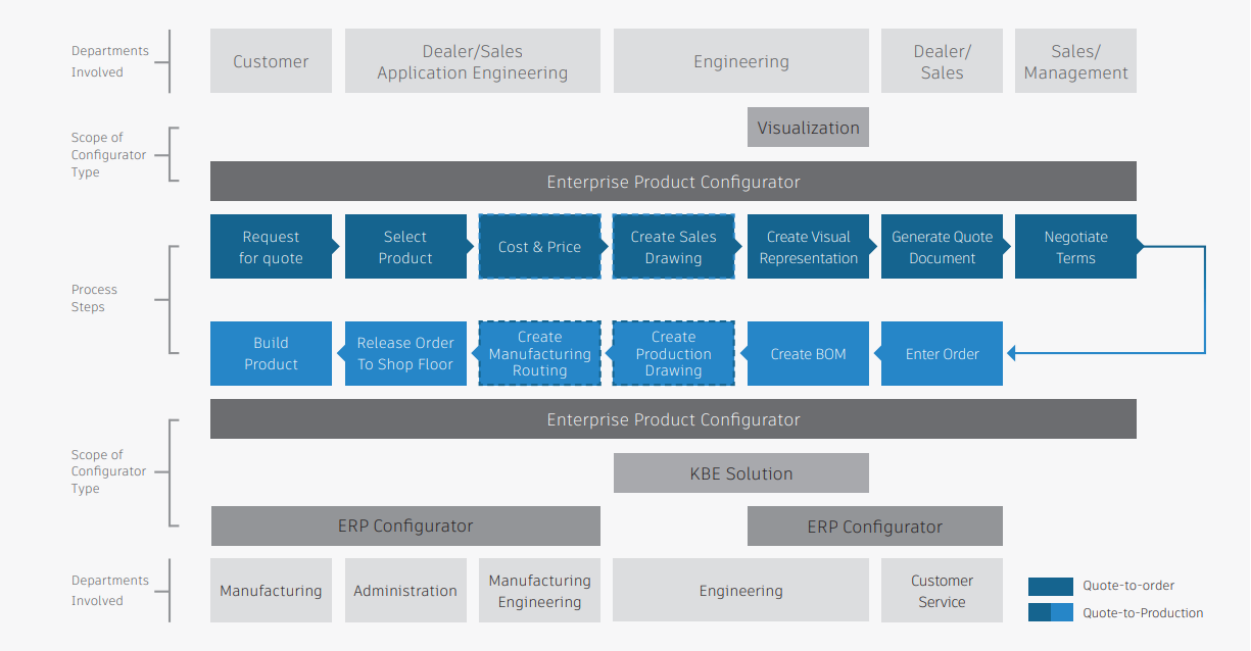
Thank you, I hope you would have found the class valuable.

Appendix

Types of a configurators

In one of the whitepapers by Autodesk, they present four major categories of configurator products available in the market. These are:

- Knowledge based engineering solutions
- ERP configurator modules
- Product visualization solutions
- Enterprise product configurators



We would advise you to go through the whitepaper to go into more details of the types based on the functionality [“Four Types of Configurators](#)”

Forge platform

"If Autodesk Forge is the engine then AWS/Azure cloud is the car build around that engine"

Autodesk Forge is a cloud service that contains almost all Autodesk CAD applications - AutoCAD, Inventor, Revit running on the servers. As a user, if you want something as simple as

changing logos in the DWG files, you just call a few APIs, get it done in the cloud. Guess what - you don't need any AutoCAD license for this service. It will be done at a fraction of a dollar conveniently.

Autodesk Forge platform also offers a CAD viewer free of cost which can fulfill the need of viewing as well as sending instructions on what to do with the data to the headless AutoCAD, Revit or Inventor running on powerful machines in the cloud.

Autodesk Forge

Autodesk Forge is perfect for creating CAD configurators as in configurators we only require a limited set of features from the entire CAD application. There is no setup time involved as we are not downloading and installing any software. You just need to consume their web APIs and pay for the time you run the service. It's just like hiring an Uber to drop you to the Airport and forget about it.

Autodesk Forge means that you can combine the strengths of different CAD modelers, translators to get your custom job done. To give you an example, Forge's translation engine can get 60 CAD file formats translated into viewable.

Even though all the CAD requirements are satisfied by the Forge platform we still need to create a complete web application around the Forge viewer and its web services. This is where AWS and Azure cloud platforms become an essential part of your application. Traditional web app development required you to rent a server space, log into the server and deploy all your source code manually and start the server-side application manually. You must also have a dedicated team to maintain the server. But in this modern era of web apps, cloud platforms have come up with excellent serverless hosting services which offload all these responsibilities from your development team.

What is serverless computing?

Serverless computing is a method of providing backend services on an as-used basis. A serverless provider allows users to write and deploy code without the hassle of worrying about the underlying infrastructure. A company that gets backend services from a serverless vendor is charged based on their computation and do not have to reserve and pay for a fixed amount of bandwidth or number of servers, as the service is auto-scaling.

The real powers of serverless from a cloud platform consumer point of view are low cost of IT infra, scalability, and automation of most of the application deployment activities by leveraging the provided services by the cloud platforms.

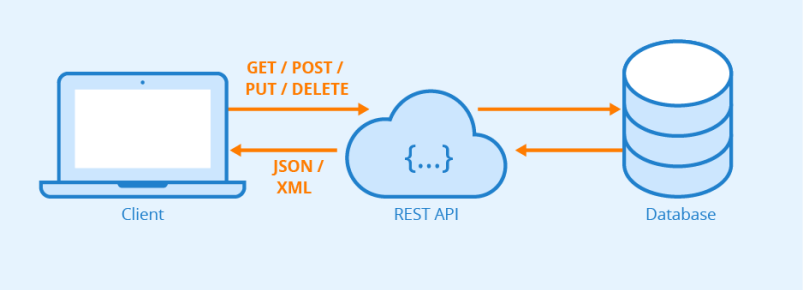
Below are the important serverless services almost every cloud service provider has:

Serverless functions:

The code written by your development team can be uploaded to a cloud platform and on the click of a button, this piece of code can be made available over the internet. Within a sec your code is ready to be executed from any internet connected device in the world. You don't need to rent a virtual server on the cloud platform, upload your code to that server, install the required dependencies, also wrap your code inside a web server of your preferred programming language like NodeJS, Java, ASP.net, Python etc, start the server and maintain it. This saves a lot of time and energy for your development team. Giving them peace of mind to simply focus on the business logic.

Serverless APIs:

Any web application necessarily always has backend from which data is served. The frontend side of the application runs in the browser/mobile device. But the backend side runs inside the cloud platform. Hence, there is a need for a communication layer between the two.

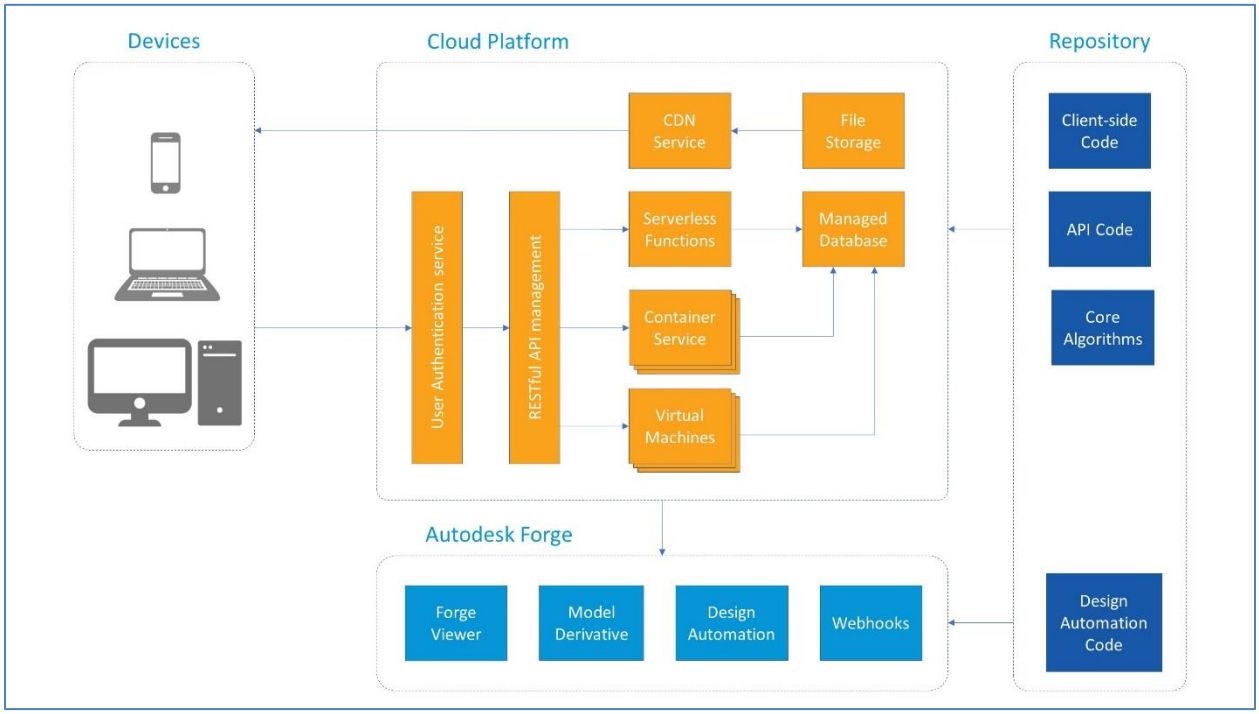


Major cloud companies provide their fully managed serverless API hosting services which can be setup in a matter of a few clicks and your application can have RESTful APIs publicly accessible in just a matter of seconds.

Serverless Databases:
Another important resource for your web app is the database. These days, cloud companies provide fully managed and scalable databases along with taking care of backup. Your development team doesn't need to worry about starting a server, installing SQL server and exposing the SQL server's port to world wide web.

General architecture of a scalable web application

Choosing the right cloud architecture is the key in making a scalable application. Modern webapps need to be written in a modular fashion for easy deployment and maintenance. But modular codebase brings in a challenge of integrating the components together in order to fulfil complex workflows. Cloud platforms have solved this challenge with what they call as "event driven architecture". Here is a generic cloud architectural diagram of a scalable web application.



General architecture of Scalability

Scalable architecture on Amazon looks like
https://aws.amazon.com/quickstart/architecture/autodesk-forge/

Static Hosting

Serving of dynamic websites can be done in multiple ways. One of the best ways is to decouple your dynamic information of your web application from static information. Static information can be served using static webpages and dynamic information would be only served when needed. Traditional web application renders their web pages on server and then it reaches to the browser whereas static websites are rendered on client side and only required minimal data is fetched from the server. Static websites can be made using multiple technologies like React, Jekyll etc.

Benefits of using static websites are

- Lighter,
- very cost effective
- Response time is also instantaneous.
- high levels of reliability
- require almost no IT administration
- get scaled to handle enterprise-level traffic with no additional work

Managed Services

Enterprises want to adapt to cloud at scale but often the skills that have served them well in traditional IT do not always translate to success in the cloud. Managed Services operate on behalf of customers, providing a proven enterprise operating model, and day-to-day infrastructure management, security control, compliance control and cost optimization.
By using the managed services offered by the cloud service providers, the enterprise can scale up their infrastructure as needed, or even migrate to cloud based services if the current setup exists in traditional means.

Benefits compared to Traditional IT

- 24x7 availability as per work demands
- Proactive monitoring of all business applications
- Providing massively scalable Solutions
- Core competency in multiple domain for application

Need of Application Security

Cloud security is important for both business and personal users. Everyone wants to know that their information is safe and secure, and businesses have legal obligations to keep client data secure, with certain sectors having more stringent rules about data storage. Security is an essential element of your cloud service. It is essential that the service provider can provide the correct levels of security for your industry.

Both AWS and Azure are compliant with global security standards as follows.

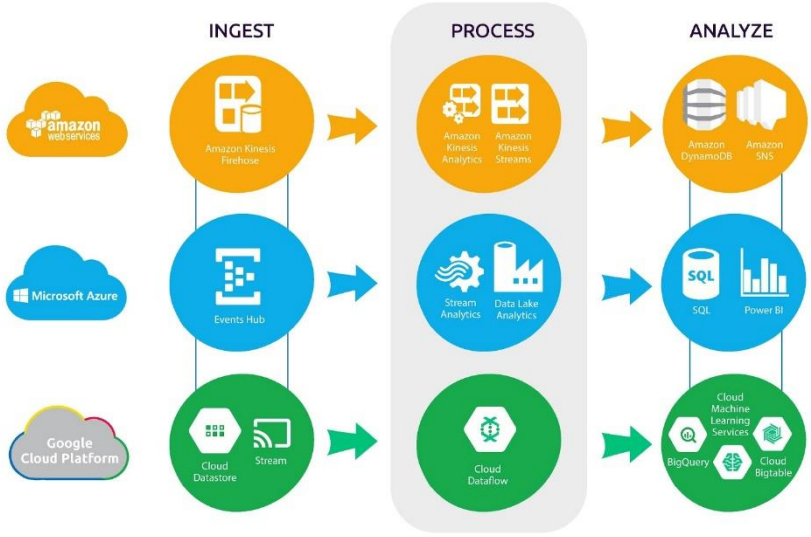
- SOC 1/ISAE 3402, SOC 2, SOC 3
- FISMA, DIACAP, and FedRAMP
- PCI DSS Level 1
- ISO 9001, ISO 27001, ISO 27017, ISO 27018

Need of information analytics

Data analytics is important because it helps businesses optimize their performances. By implementing it into the business model companies can help reduce costs by identifying more efficient ways of doing business.

A company can also use data analytics to make better business decisions and help analyse customer trends and satisfaction, which can lead to new—and better—products and services.

Cloud based architecture provides a seamless way to store and analyse data, and also give the benefit to provide quick implementation strategies.



Data Analytics in different cloud services

Select appropriate computing services from various cloud platforms

For any web application the underlying computation resource is the most important service provided by cloud platforms. It is also a major portion of the running cost. Computation requirements of workloads can vary drastically between different use cases. Two different applications having the same business value for an organization can have huge differences in the workloads. One use case may have tiny logic which can be processed in serverless functions whereas the other can have HPC machines involved. It is important to understand the computation needs of each component of your application. Based on these needs, the whole cloud architecture gets designed.

There are 3 major computation resources available in the serverless space:

- Functions
- docker containers and
- batch jobs

For tiny computation needs serverless functions are the right way to go with. If the processing need of a particular operation is more and takes quite a while to complete, then docker container is preferable. And if computation need is such that it requires multi-core support and extremely large amount of memory then large computing instances running batch processing is preferable.

Amazon Compute Services

Compute Type	Core Limit	Memory Limit	Time Limit
Lambda	More than one CPU	128 to 3008 MB	15 minutes
Fargate	4 Cores	30 GB	No limit
Batch	96 Cores	768 GB	No limit
Parallel Cluster	96 Cores	768 GB	No limit

Azure Compute Services

Compute Type	Core Limit	Memory Limit	Time Limit
Azure Functions	250 ACU	3.5 - 14 GB	No limit
Container Instances	24	448 GB	No limit
Batch	120	480 GB	180 days
CycleCloud	120	480 GB	No limit