

Technical Report:

Multi-Platform Cloud Deployment & Comparative Analysis

Optimizing Static Web Hosting for Scalability and Cost-Efficiency

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Summary

This report evaluates the deployment of a static Hugo-based web application across three distinct Microsoft Azure service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Object Storage. The objective is to determine the optimal hosting environment based on cost-optimization, service availability (SLAs), and operational overhead.

Implementation Overview

The deployment was executed across three environments to test the versatility of the Hugo static site engine:

A. Infrastructure as a Service (VM Deployment)

- **Environment:** Linux Virtual Machine (Ubuntu).
- **Web Server:** Configured Nginx for high-performance static file serving.
- **Workflow:** Leveraged Git-based deployment for seamless file transfer from local environment to the production VM.

B. Platform as a Service (Azure App Service)

- **Environment:** Managed PaaS (App Service).
- **Deployment Method:** Utilized SCM & FTP integration for optimized artifact deployment.
- **Key Insight:** Optimized the deployment speed by implementing a Zip-based artifact transfer via Kudu File Manager, significantly reducing deployment latency compared to individual file uploads.

C. Cloud Object Storage (Azure Blob Storage)

- **Environment:** Serverless Static Website Hosting via Azure Blob Storage.
- **Configuration:** Enabled anonymous public access and configured specific index/error document endpoints.
- **Storage:** Direct deployment to the \$web container, bypassing server management entirely.

All resources overview

Resource Manager - Microsoft Azure - Brave

portal.azure.com/?Microsoft_Azure_Education_correlationId=7fe25a4f-ced8-48cc-9459-e3767134f619&Mic...

Main | Ice | KAUST Stage 2... | FastAPI - A python f... | The Mini V2: r/ianli | for watching | Learning | BB | Welcome | About Fahad Alshehri | Claude

Microsoft Azure | Search resources, services, and docs (Ctrl+K) | Copilot

Home > Resource Manager

Resource Manager | All resources

What platform metrics apply to these resources | Review capacity errors across resources | Generate Bicep code for managing multiple resources

Search

+ Create | Manage view | Refresh | Export to CSV | Open query | Assign tags | Delete | Add to service group | Group by none

You are viewing a new version of Resource experience. Click here to access the old experience.

Filter for any field... | Subscription equals all | Resource Group equals all | Type equals all | Location equals all | Add filter

Name	Type	Resource Group	Location	Subscription
ASP-cp8490-92bt	App Service plan	cp8490	Switzerland North	Azure for Students
blubdorgar/fahad	Storage account	cp8490	Switzerland North	Azure for Students
hugo	Virtual machine	cp8490	Switzerland North	Azure for Students
hugo-fahad	App Service	cp8490	Switzerland North	Azure for Students
hugo-fahad2	App Service	cp8490	Switzerland North	Azure for Students
hugo-ip	Public IP address	cp8490	Switzerland North	Azure for Students
hugo-nsg	Network security group	cp8490	Switzerland North	Azure for Students
hugo-vnet	Virtual network	cp8490	Switzerland North	Azure for Students
hugo/39_11	Network interface	cp8490	Switzerland North	Azure for Students
hugo_OsDisk_1_4ac508586936454e95c297d1bcd56c179	Disk	CP1490	Switzerland North	Azure for Students
NetworkWatcher-switzerlandnorth	Network Watcher	NetworkWatcherRG	Switzerland North	Azure for Students

Showing 1 - 11 of 11. Display count: 200

Give feedback

Add or remove Resources by pressing Ctrl + Shift + F

Windows taskbar: File Explorer, Edge, Teams, Outlook, WhatsApp, Messenger, Zoom, OneDrive, etc.

System tray: ENG US, 6:11 PM, 12/28/2025

Prerequisites: downloading hugo and testing it

```
Command Prompt - hugo ser x + v
--tlsKeyFile string      path to TLS key file
--traceFile string       write trace to file (not useful in general)
--w, --watch             match filesystem for changes and recreate as needed (default true)

Global Flags:
--clock string           set the clock used by Hugo, e.g. --clock 2021-11-06T22:30:00.00+09:00
--config string          config file (default is hugo.yaml|json|toml)
--configDir string       config dir (default "config")
--d, --destination string filesystem path to write files to
--e, --environment string build environment
--ignoreVendorPaths string ignores any _vendor for module paths matching the given Glob pattern
--logLevel string        log level (debug|info|warn|error)
--noBuildLock            don't create .hugo_build.lock file
--quiet                 build in quiet mode
--H, --renderToMemory    render to memory (mostly useful when running the server)
--s, --source string      filesystem path to read files relative from
--themesDir string       filesystem path to themes directory

Use "hugo server [command] --help" for more information about a command.

ERROR command error: failed to load config: "C:\Users\Fahad\quickstart\hugo.toml:4:20": unmarshal failed: toml: expected character =
C:\Users\Fahad\quickstart>notepad hugo.toml

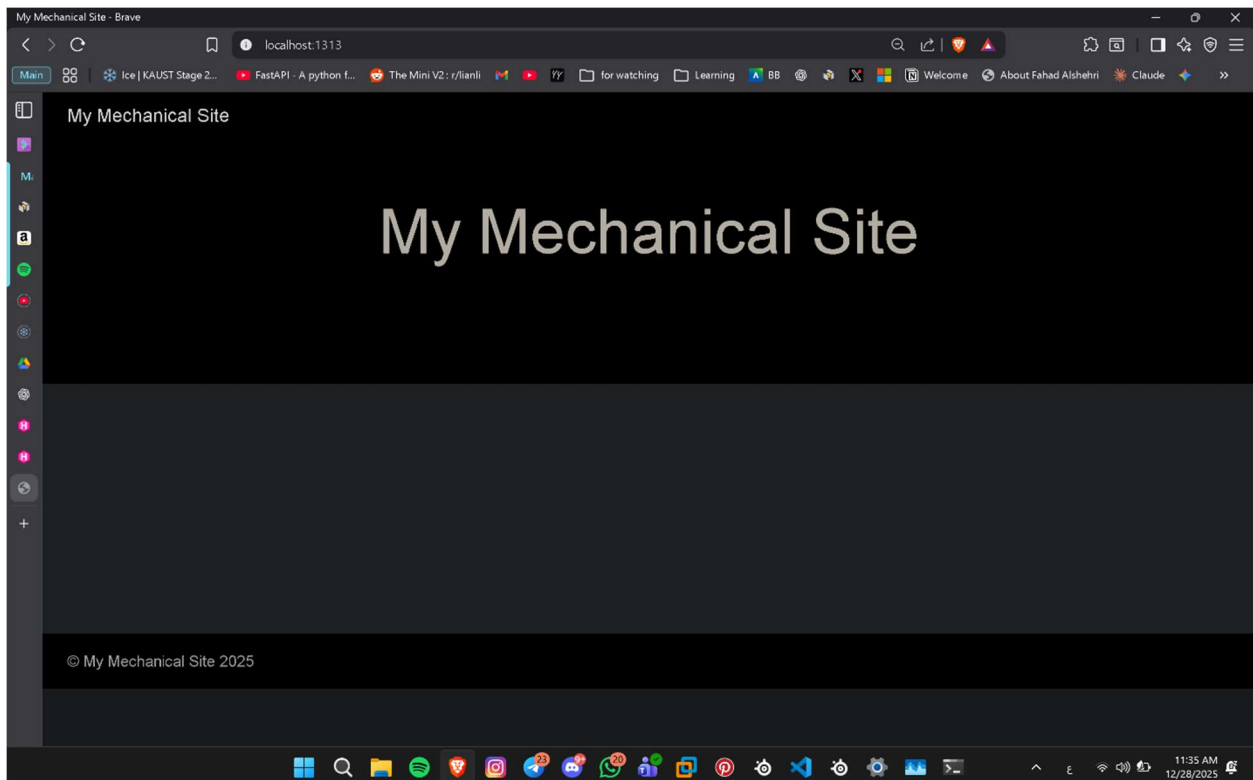
C:\Users\Fahad\quickstart>hugo server
Watching for changes in C:\Users\Fahad\quickstart\archetypes, C:\Users\Fahad\quickstart\assets, C:\Users\Fahad\quickstart\content, C:\Users\Fahad\quickstart\data, C:\Users\Fahad\quickstart\i18n, C:\Users\Fahad\quickstart\layouts, C:\Users\Fahad\quickstart\static, C:\Users\Fahad\quickstart\themes\ananke\archetypes, C:\Users\Fahad\quickstart\themes\ananke\assets\ananke, C:\Users\Fahad\quickstart\themes\ananke\i18n, C:\Users\Fahad\quickstart\themes\ananke\layouts\{,_partials,_shortcodes,page,post}, C:\Users\Fahad\quickstart\themes\ananke\package.hugo.json, C:\Users\Fahad\quickstart\themes\ananke\package.json, C:\Users\Fahad\quickstart\themes\ananke\static\images
Watching for config changes in C:\Users\Fahad\quickstart\hugo.toml, C:\Users\Fahad\quickstart\themes\ananke\config.default
Start building sites ...
hugo v0.153.2-798533a2013eab97198b0a155a8f4fab7e79865+extended windows/amd64 BuildDate=2025-12-22T16:53:01Z VendorInfo=gohugoio


```

	EN
Pages	0
Paginator pages	0
Non-page files	0
Static files	1
Processed images	0
Aliases	0
Cleaned	0

```
Built in 241 ms
Environment: "development"
Serving pages from disk
Running in Fast Render Mode. For full rebuilds on change: hugo server --disableFastRender
Web Server is available at http://localhost:1313/ (bind address 127.0.0.1)
Press Ctrl+C to stop
```

Accessing hugo site before doing deployments



VM Deployment: VM creation

The screenshot displays the Microsoft Azure portal interface. The top navigation bar shows the 'hugo' virtual machine under 'Compute infrastructure | Virtual machines'. The left sidebar contains various management tools like Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Resource visualizer, Connect, Bastion, Networking, Network settings, Load balancing, Application security groups, Network manager, Settings, Availability + scale, Security, Backup + disaster recovery, Operations, Monitoring, Automation, and Help. The main content area shows the 'Essentials' tab for the 'hugo' VM. Key details include: Resource group (movov), Status (Running), Location (Switzerland North (Zone 1)), Subscription (Azure for Students), Subscription ID (8e0719ae-9ae3-43f5-8a5f-9ab94ee06ac5), Availability zone (1), Operating system (Linux (ubuntu 24.04)), Size (Standard B1ms (1 vcpu, 2 GiB memory)), Primary NIC public IP (74.161.40.53), Virtual network/subnet (hugo-vnet/default), DNS name (Not configured), Health state (-), and Time created (12/28/2025, 11:23 AM UTC). Below the Essentials tab, the 'Properties' section lists VM details: Computer name (hugo), Operating system (Linux (ubuntu 24.04)), VM generation (V2), VM architecture (x64), Agent status (Ready), Agent version (2.15.0.1), Hibernation (Disabled), and Host group (-). The 'Networking' section shows the Public IP address (74.161.40.53) and associated public IPs (1 associated public IPs).

Downloading Nginx on VM

The screenshot shows a terminal window with the following output:

```
The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

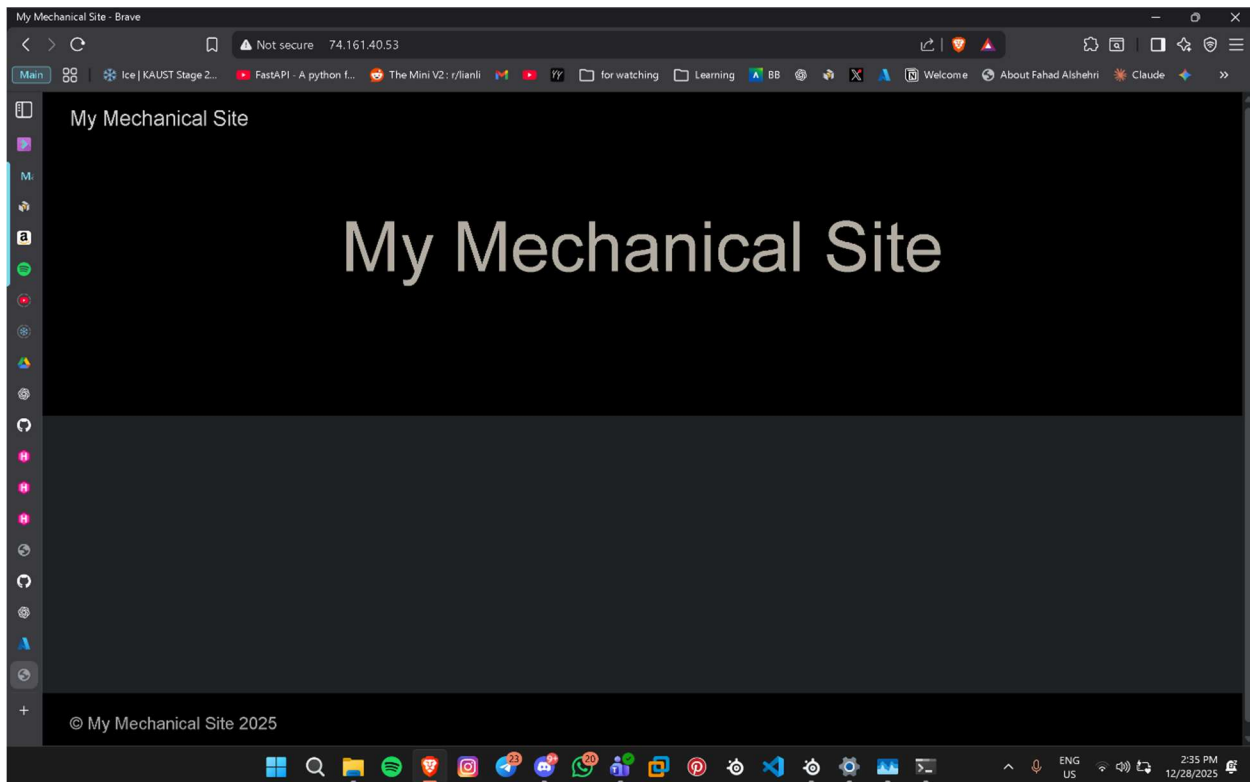
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

azureuser@hugo: $ sudo apt install nginx
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following additional packages will be installed:
  nginx-common
Suggested packages:
  fcgiwrap nginx-doc ssl-cert
The following NEW packages will be installed:
  nginx nginx-common
0 upgraded, 2 newly installed, 0 to remove and 0 not upgraded.
Need to get 564 kB of archives.
After this operation, 1596 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://azure.archive.ubuntu.com/ubuntu noble-updates/main amd64 nginx-common all 1.24.0-2ubuntu7.5 [43.4 kB]
Get:2 http://azure.archive.ubuntu.com/ubuntu noble-updates/main amd64 nginx amd64 1.24.0-2ubuntu7.5 [520 kB]
Fetched 564 kB in 0s (7567 kB/s)
Preconfiguring packages ...
Selecting previously unselected package nginx-common.
(Reading database ... 68451 files and directories currently installed.)
Preparing to unpack .../nginx-common_1.24.0-2ubuntu7.5_all.deb ...
Unpacking nginx-common (1.24.0-2ubuntu7.5) ...
Selecting previously unselected package nginx.
Preparing to unpack .../nginx_1.24.0-2ubuntu7.5_amd64.deb ...
Unpacking nginx (1.24.0-2ubuntu7.5) ...
Setting up nginx-common (1.24.0-2ubuntu7.5) ...
Created symlink /etc/systemd/system/multi-user.target.wants/nginx.service → /usr/lib/systemd/system/nginx.service.
Setting up nginx (1.24.0-2ubuntu7.5) ...
* Upgrading binary nginx
Progress: [ 78%] [#####.....]
```

Moving files to VM using git clone to deploy

```
Command Prompt x Command Prompt x Ubuntu x Ubuntu x + v
azureuser@hugo: $ git clone https://github.com/FahadAlshehri/hugo-static-app-fahad
Cloning into 'hugo-static-app-fahad'...
remote: Enumerating objects: 31, done.
remote: Counting objects: 100% (31/31), done.
remote: Compressing objects: 100% (18/18), done.
remote: Total 31 (delta 5), reused 31 (delta 5), pack-reused 0 (from 0)
Receiving objects: 100% (31/31), 313.29 KiB | 8.24 MiB/s, done.
Resolving deltas: 100% (5/5), done.
azureuser@hugo: $ cd hugo-static-app-fahad/
azureuser@hugo:~/hugo-static-app-fahad$ sudo cp -r public/* /var/www/html/
azureuser@hugo:~/hugo-static-app-fahad$ cd ~
azureuser@hugo: $ cd var/www/html/
-bash: cd: var/www/html/: No such file or directory
azureuser@hugo: $ cd var/www/html
-bash: cd: var/www/html: No such file or directory
azureuser@hugo: $ cd /var/www/html
azureuser@hugo: $ cd /var/www/html
azureuser@hugo:/var/www/html$ ls
404.html ananke categories images index.html index.nginx-debian.html index.xml sitemap.xml tags
azureuser@hugo:/var/www/html$ sudo rm *
rm: cannot remove 'ananke': Is a directory
rm: cannot remove 'categories': Is a directory
rm: cannot remove 'images': Is a directory
rm: cannot remove 'tags': Is a directory
azureuser@hugo:/var/www/html$ sudo rm * --force
rm: cannot remove 'ananke': Is a directory
rm: cannot remove 'categories': Is a directory
rm: cannot remove 'images': Is a directory
rm: cannot remove 'tags': Is a directory
azureuser@hugo:/var/www/html$ sudo rm * -rf
azureuser@hugo:/var/www/html$ ls
azureuser@hugo:/var/www/html$ sudo cp -r hugo-static-app-fahad/public/* /var/www/html/
cp: cannot stat 'hugo-static-app-fahad/public/*': No such file or directory
azureuser@hugo:/var/www/html$ cd ~
azureuser@hugo: $ ls
hugo-static-app-fahad
azureuser@hugo: $ cd hugo-static-app-fahad/
azureuser@hugo:~/hugo-static-app-fahad$ ls
archetypes hugo.toml public resources themes
azureuser@hugo:~/hugo-static-app-fahad$ sudo cp -r public/* /var/www/html/
azureuser@hugo:~/hugo-static-app-fahad$
```

Site on VM using VM IP



PaaS Deployment: Creation

The screenshot displays the Microsoft Azure portal interface. The left-hand navigation pane shows the 'Overview' page selected for the Web App 'hugo-fahad'. The main content area is divided into two sections: 'Essentials' and 'Properties'.

Essentials:

- Resource group: [cpu490](#)
- Status: Running
- Location: Switzerland North
- Subscription: [Azure for Students](#)
- Subscription ID: 8e0719ae-9ac3-43f5-ba5f-9ab94ee06ac5
- Tags: Add tags
- Default domain: [hugo-fahad-c7hpluddfshq4thgswitzerlandnorth-01.azurewebsites.net](#)
- App Service Plan: ASP-cpu490-92bf (B1-1)
- Operating System: Linux
- Health Check: Not Configured
- Git/Deployment username: null
- Git clone url: https://null@hugo-fahad-c7hpluddfshq4thgswitzerlandnorth-01.azurewebsites.net:git

Properties:

Section	Property	Value
Web app	Name	hugo-fahad
	Publishing model	Code
	Runtime Stack	Php - 8.4
	Runtime status	Healthy
Domains	Default domain	hugo-fahad-c7hpluddfshq4thgswitzerlandnorth-01.azurewebsites.net
	Custom domain	Add custom domain
Hosting	Plan Type	App Service plan
	Name	ASP-cpu490-92bf

The right-hand pane shows 'JSON View' of the configuration, including 'Deployment Center' (Deployment logs, Last deployment, Deployment provider), 'Application Insights' (Name, Not supported), and 'Networking' (Virtual IP address, Outbound IP addresses, Additional Outbound IP addresses).

Enabling SCM & FTP

The screenshot displays the Microsoft Azure portal interface, showing the 'General settings' page for the Web App 'hugo-fahad'. The left-hand navigation pane shows the 'Configuration (preview)' page selected. The main content area is divided into two sections: 'General settings' and 'Stack settings'.

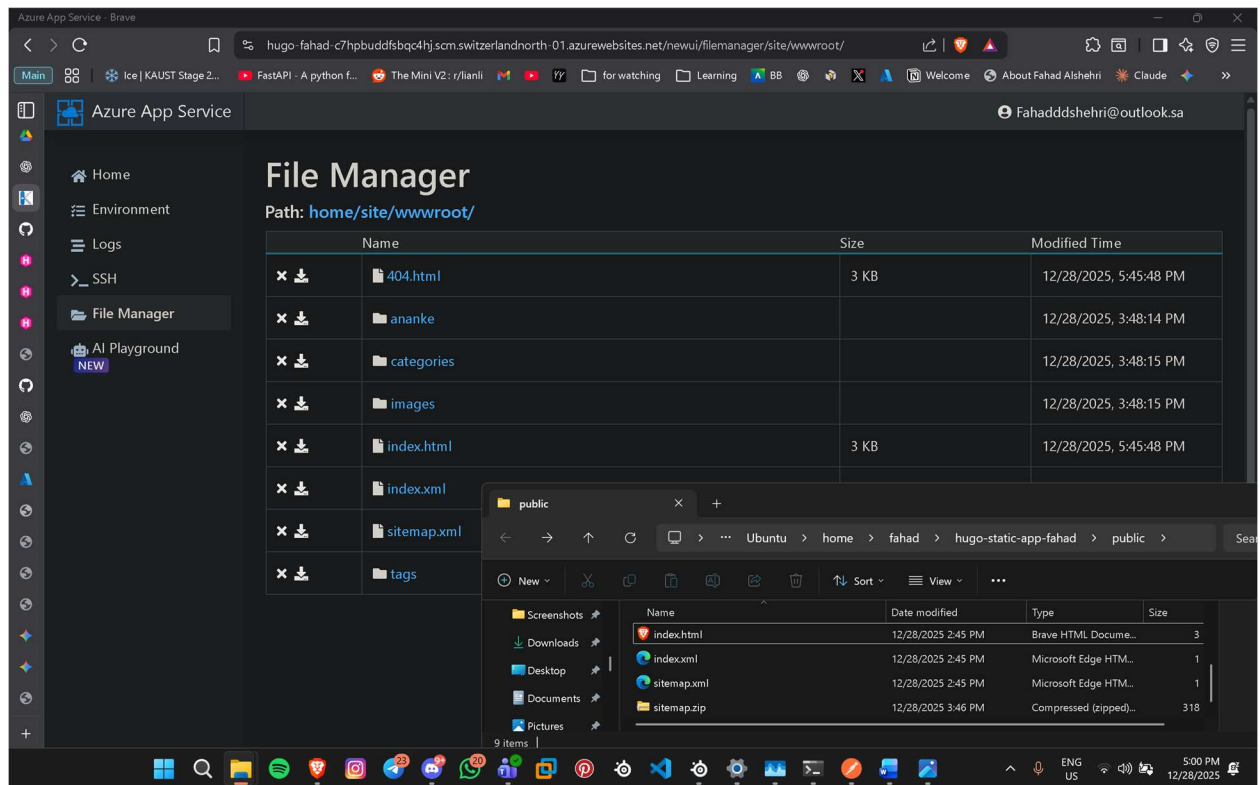
General settings:

- Platform settings
- SCM Basic Auth Publishing Credentials: ☒
- FTP Basic Auth Publishing Credentials: ☒
- FTP state: FTPS only
- Inbound IP mode: IPv4
- HTTP version: 1.1
- HTTP 2.0 Proxy: Off
- SSH: ☒
- Always on: ☐
- Session affinity: ☐
- Session affinity proxy: ☐
- HTTPS only: ☒
- Minimum Inbound TLS Version: 1.2
- Minimum Inbound TLS Cipher Suite: TLS_RSA_WITH_AES_128_GCM_SHA256 (Default) Change
- Debugging: ☐

The right-hand pane shows 'Apply' and 'Discard' buttons.

Using Kudo file manager to put zipped file “sitemap.zip” that compressed public directory files

Note: tried multiple ways but zip file method is the best and fast



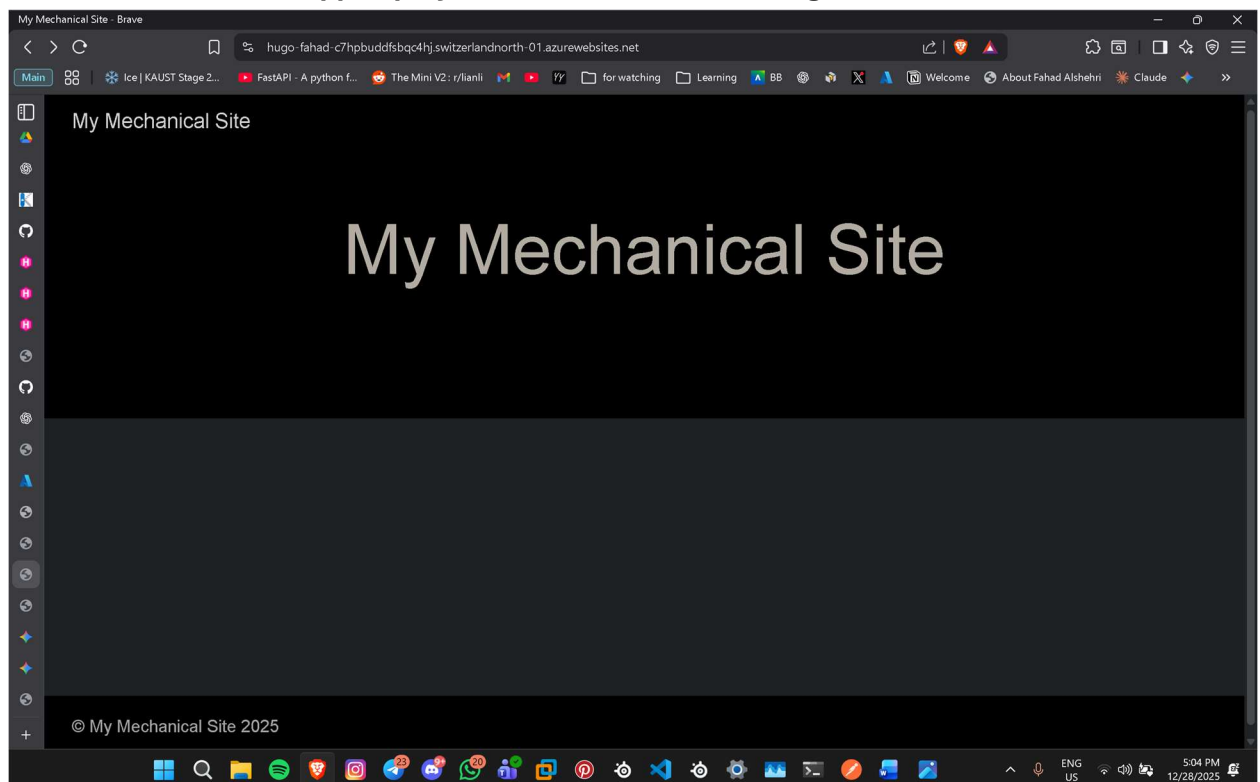
The screenshot shows the Azure App Service File Manager interface. The left sidebar contains navigation options: Home, Environment, Logs, SSH, File Manager (selected), and AI Playground. The main area displays the File Manager for the path `home/site/wwwroot/`. A table lists the following files and folders:

Name	Size	Modified Time
404.html	3 KB	12/28/2025, 5:45:48 PM
ananke		12/28/2025, 3:48:14 PM
categories		12/28/2025, 3:48:15 PM
images		12/28/2025, 3:48:15 PM
index.html	3 KB	12/28/2025, 5:45:48 PM
index.xml		
sitemap.xml		
tags		

A file explorer window is open over the 'public' directory, showing a list of files and folders:

Name	Date modified	Type	Size
index.html	12/28/2025 2:45 PM	Brave HTML Docume...	3
index.xml	12/28/2025 2:45 PM	Microsoft Edge HTM...	1
sitemap.xml	12/28/2025 2:45 PM	Microsoft Edge HTM...	1
sitemap.zip	12/28/2025 3:46 PM	Compressed (zipped)...	318

App deployed on PaaS as seen url “hugo-fahad...”



The screenshot shows the deployed web application. The browser address bar displays the URL `hugo-fahad-c7hpbuddfsbqc4hj.scm.switzerlandnorth-01.azurewebsites.net`. The page content includes the title "My Mechanical Site" and a large heading "My Mechanical Site". The footer text reads "© My Mechanical Site 2025".

Object Storage Deployment:

The screenshot displays the Microsoft Azure portal interface for a storage account named 'blobstorgaefahad'. The left sidebar shows the navigation menu with options like Overview, Activity log, Tags, Diagnose and solve problems, Access Control (IAM), Data migration, Events, Storage browser, Storage Mover, Partner solutions, Resource visualizer, Data storage (Containers, File shares, Queues, Tables), Security + networking (Networking, Front Door and CDN, Access keys, Shared access signature, Encryption), and Settings (Storage Actions, Redundancy, Data protection, Object replication, Blob inventory, Static website, Lifecycle management, Azure AI Search, Configuration).

The main content area shows the 'Essentials' tab for the storage account. It lists key details: Resource group (crlk490), Location (switzerlandnorth), Subscription (Azure for Students), Subscription ID (8e0719ae-9ae3-43f5-8a5f-9ab94ee0cac5), Disk state (Available), and Tags (Add tags). It also shows Performance (Standard), Replication (Locally redundant storage (LRS)), Account kind (StorageV2 (general purpose v2)), Provisioning state (Succeeded), and Created (12/28/2025, 3:58:00 PM).

Below the Essentials tab, there are three sections: Properties, Monitoring, and Capabilities. The Properties section is expanded, showing settings for Blob service, Security, and File service. The Blob service settings include Hierarchical namespace (Disabled), Default access tier (Hot), Blob anonymous access (Enabled), Blob soft delete (Enabled (7 days)), Container soft delete (Enabled (7 days)), Versioning (Disabled), Change feed (Disabled), NFS v3 (Disabled), and Storage tasks assignments (None). The Security section shows Require secure transfer for REST API operations (Enabled), Storage account key access (Enabled), Minimum TLS version (Version 1.2), and Infrastructure encryption (Disabled). The File service settings include Large file share (Enabled), Identity-based access (Not configured), Default share-level permissions (Disabled), and Soft delete (Enabled (7 days)).

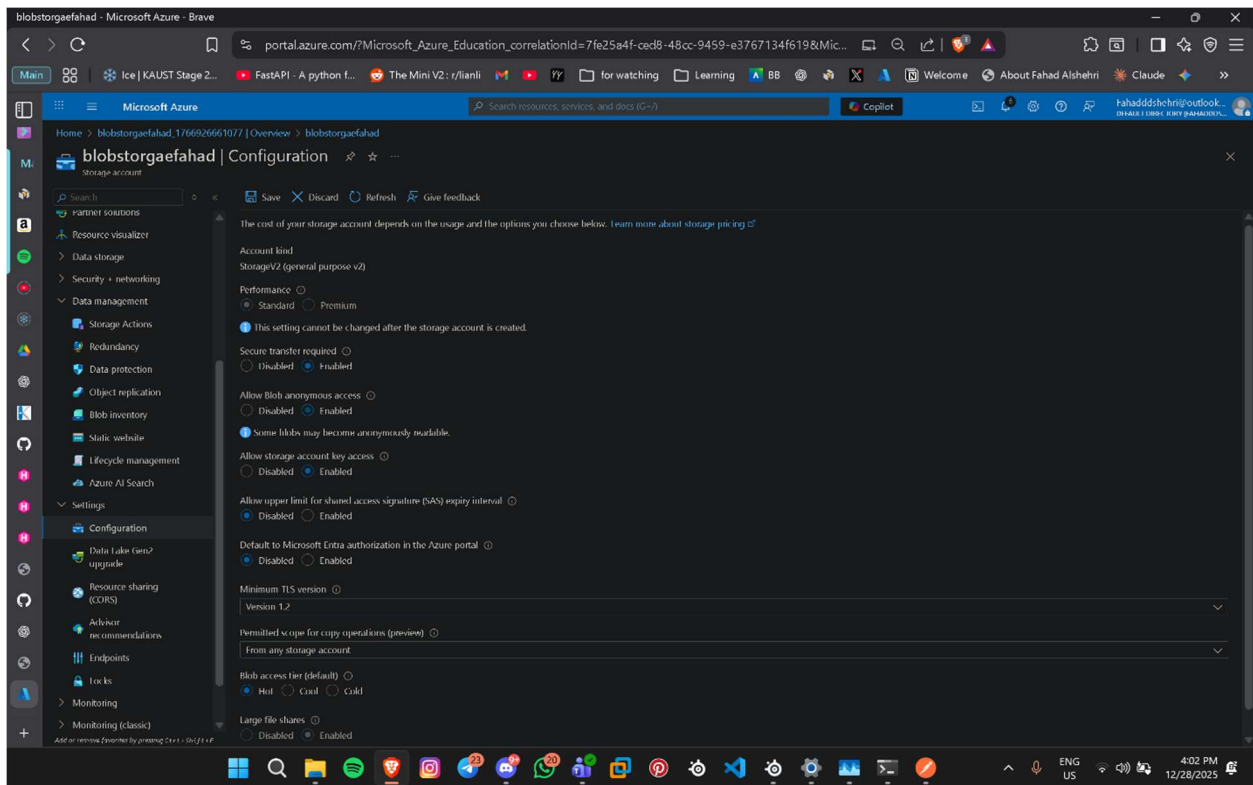
Endpoint url & index,error docs to use to show site

The screenshot displays the Microsoft Azure portal interface for a storage account named 'blobstorgaefahad', specifically the 'Static website' configuration page. The left sidebar shows the navigation menu with options like File shares, Queues, Tables, Security + networking (Networking, Front Door and CDN, Access keys, Shared access signature, Encryption), Microsoft Defender for Cloud, Data management (Storage Actions, Redundancy, Data protection, Object replication, Blob inventory, Static website, Lifecycle management, Azure AI Search), and Settings (Configuration).

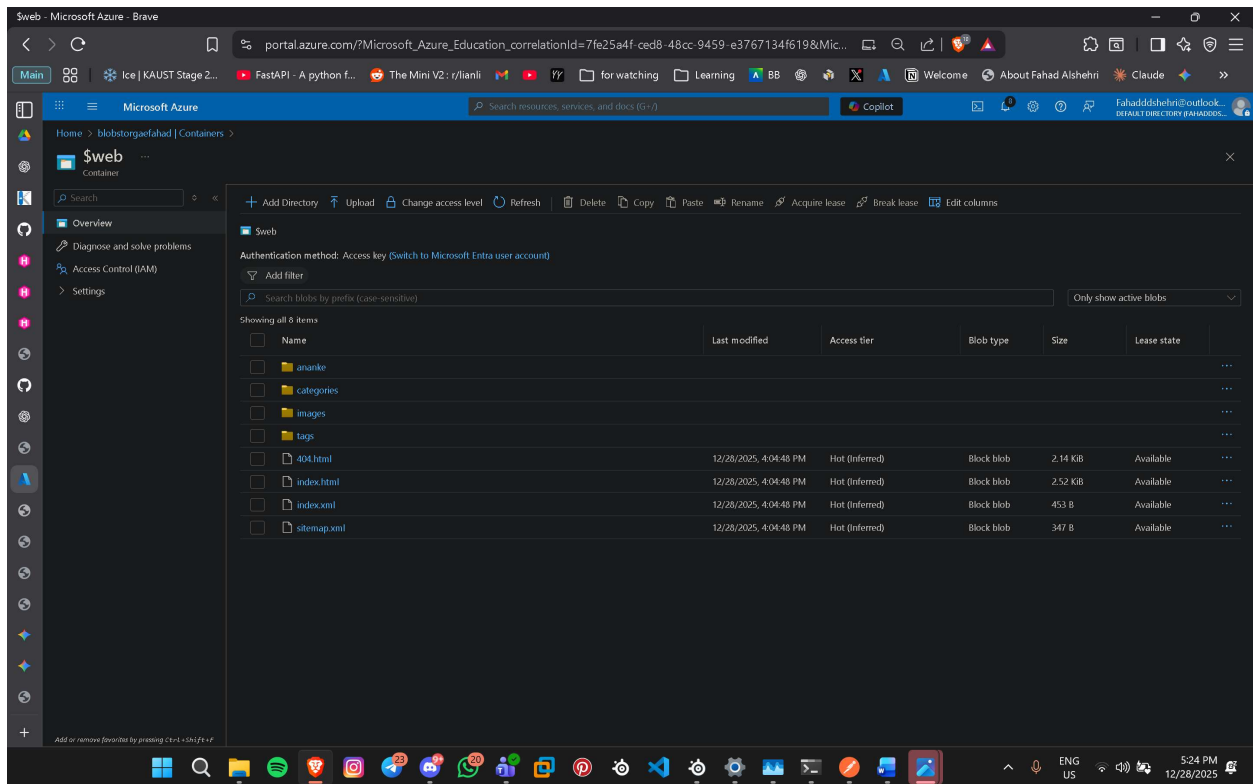
The main content area shows the 'Static website' configuration page. It includes a description: 'Enabling static websites on the blob service allows you to host static content. Webpages may include static content and client-side scripts. Server-side scripting is not supported. As data is replicated asynchronously from primary to secondary regions, files at the secondary endpoint may not be immediately available or in sync with files at the primary endpoint. [Learn more](#)'. It also shows a toggle for 'Static website' set to 'Enabled'.

Below the description, there is a section for 'Web' configuration. It includes a tip: 'Improve the page load time of your static website by using the caching features of Azure Front Door (Additional costs apply). [Azure Front Door](#)'. It also shows the 'Primary endpoint' as 'https://blobstorgaefahad.z1.web.core.windows.net/'. The 'Index document name' is set to 'index.html' and the 'Error document path' is set to '404.html'.

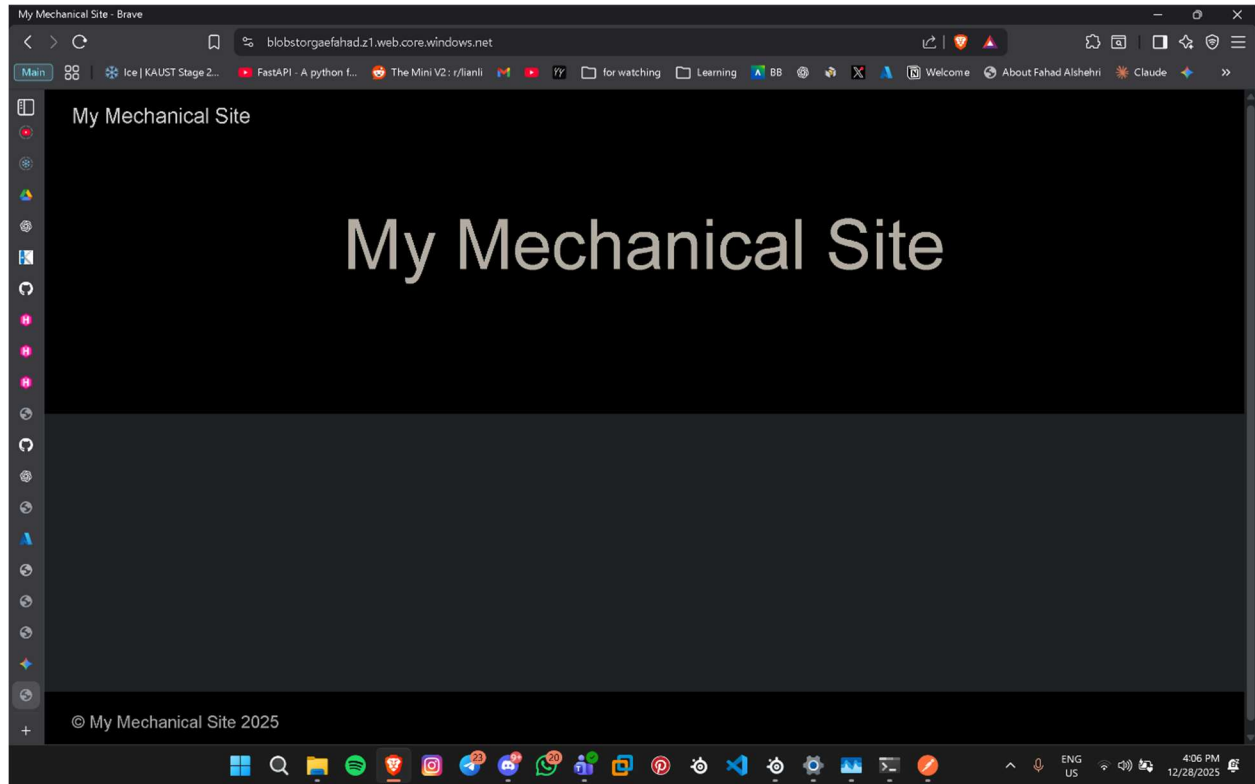
Enabling anonymous blob access to allow public access to site resources



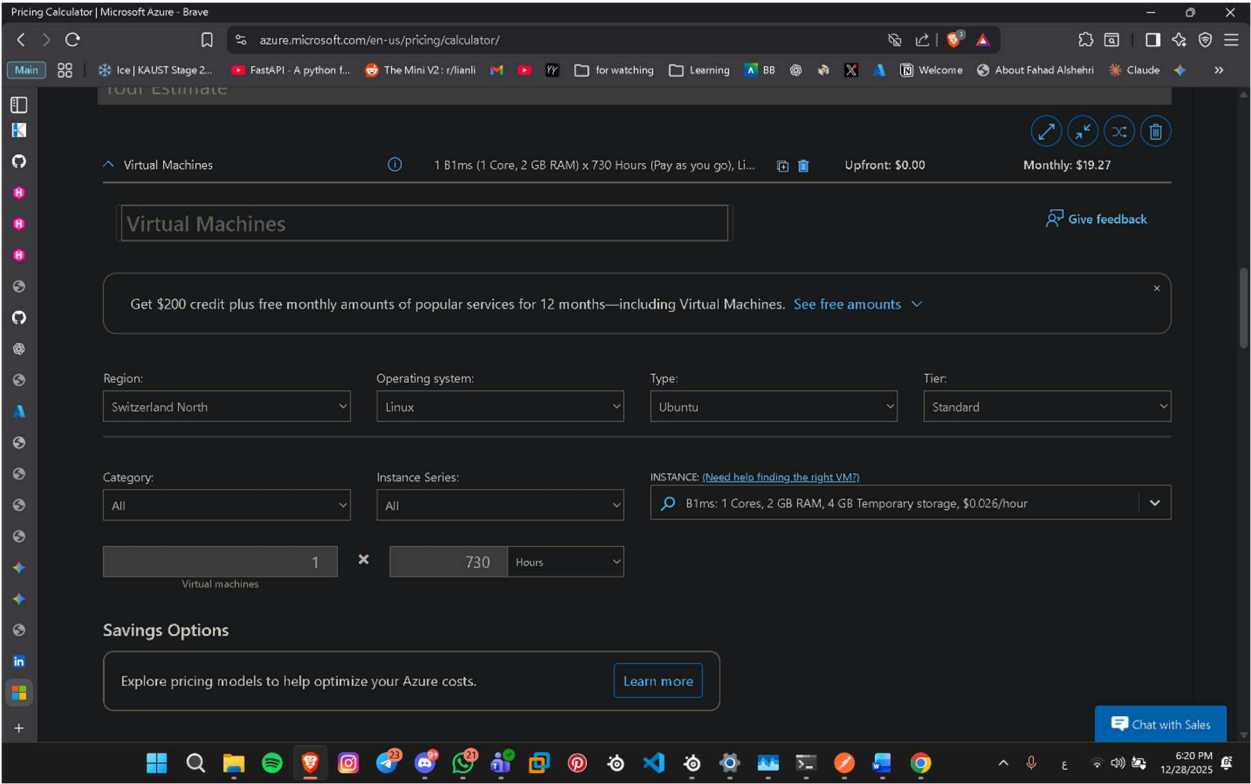
Upload of the Hugo site files HTML, XML etc.. in the \$web container in Azure Blob Storage



Accessing the live static website using the endpoint



Prices Of Each VM, PaaS, Object Storage



VM Cost: \$19.27 monthly

Pricing Calculator | Microsoft Azure - Brave

azure.microsoft.com/en-us/pricing/calculator/

Main

App Service

Basic Tier, 1 B1 (1 Core(s), 1.75 GB RAM, 10 GB Storage) x 730

Upfront: \$0.00 Monthly: \$14.45

App Service

Region: Switzerland North Operating system: Linux Tier: Basic

Basic

INSTANCE:

B1: 1 Core(s), 1.75 GB RAM, 10 GB Storage, \$0.020

1 x 730 Hours = \$14.45

SSL Connections \$0.00

Custom Domain and Certificates \$0.00

Upfront cost \$0.00

Monthly cost \$14.45

Support

SUPPORT: Basic (Included)

Chat with Sales

PaaS Cost: \$14.45 monthly

Pricing Calculator | Microsoft Azure - Brave

azure.microsoft.com/en-us/pricing/calculator/

Main

Storage Accounts

Block Blob Storage, General Purpose V2, Flat Namespace, LRS

Upfront: \$0.00 Monthly: \$1.15

Storage Accounts

Get \$200 credit plus free monthly amounts of popular services for 12 months—including Block Blob Storage, Standard tier. See free amounts

Region: Switzerland North Type: Block Blob Storage Performance: Standard Storage Account Type: General Purpose V2

File Structure: Flat Namespace Access tier: Hot Redundancy: LRS

Capacity

1 GB

Savings Options

Save up to 38% on pay-as-you-go prices with 1-year or 3-year Azure Storage Reserved Capacity. Learn more about Azure Storage Reserved Capacity pricing.

Pay as you go

Pay as you go

Chat with Sales

Blob price: \$1.15 monthly

Outbound Data Transfer



5
GB

The first 5 GB/Month of Inter Region data transfer and the first 100 GB/Month of Internet Egress data transfer are free in each zone.

Since the first 100GB of data transfer is free on Azure, setting the limit to 2GB will not add any cost to the monthly estimate

Pricing comparison:

Estimated for 10,000 monthly visitors / 2GB Bandwidth.

Component	VM	PaaS	Object storage
Compute/Storage	\$19.27 / month (Standard B1ms Instance)	\$14.45 / month (Basic B1 Tier)	\$1.15 / month (Standard, LRS)
Bandwidth (2GB)	(First 100GB/mo is free) \$0	(First 100GB/mo is free) \$0	(First 100GB/mo is free) \$0
Total Monthly Cost	\$19.27	\$14.45	\$1.15

Availability analysis:

Component	VM	PaaS	Object storage
SLAs	95% (Standard HDD)	99.95%	99.9%
Redundancy	Manually must configure backups	Automatic Azure manages hardware & runtime redundancy	Automatic Done by azure (LRS)
Failure Points	High, Risk of OS failure, single disk failure, and misconfiguration	Dependent on runtime stack and region uptime	Lower, no OS or server management risks

Recommendation:

I recommend option 3 (**Object storage**)

Cost: It is the cheapest option by far and It only costs about (\$1.15) per month. The other options cost between (\$14.45) and (\$19.27) per month and Paying that much for a static website that doesn't need a server is just a waste of money.

Reliability: a static site doesn't need a complex server to run, This makes it safer because there is no OS to update and no risk of a server crash It also has a better uptime guarantee (99.9%) compared to the VM (only 95%).

Scalability: Azure handles the traffic automatically If the site suddenly gets a lot of visitors, Object storage will handle it without any issues and no need to manually add more servers or change settings.

Future Roadmap: DevOps Integration

As a next phase, the goal is to transition these manual deployments into a fully automated **CI/CD Pipeline** using:

- **Infrastructure as Code (IaC):** Leveraging **Terraform** to provision the Azure resources.
- **Continuous Deployment:** Using **GitHub Actions** to automate site builds and deployments upon every code push, ensuring a modern DevOps workflow.