**Cloud Landscape Review for Application Developers**

Part 1: Online Cloud Resources

**Amazon Web Services (AWS)**

[The 17 Ways to Run Containers on AWS - Last Week in AWS Blog](https://www.lastweekinaws.com/blog/the-17-ways-to-run-containers-on-aws/)

This article covers 12 ways to run web application containers on AWS. AWS Lambda, Elastic Beanstalk, Fargate, ECS, EKS, EC2, Lightsail, Lightsail Containers, App Runner, and Proton can run and host while tools like AWS Copilot and App2Container simplify configuring and deploying existing applications. This is a reputable source but can be hard to understand for those unfamiliar with the industry.

[Aurora vs. RDS: An Engineer's Guide to Choosing a Database - LWIA Blog (lastweekinaws.com)](https://www.lastweekinaws.com/blog/aurora-vs-rds-an-engineers-guide-to-choosing-a-database/)

AWS provides all the standard database systems and supports all major database engines with RDS. However, they also include their custom engine, known as Aurora. RDS delivers all the same features as the classic on-premises database. Aurora has a cloud-first architecture, enabling AWS to optimize throughput, resiliency, and size. At first, Aurora may seem superior in all ways, but there are limitations. For example, it only supports MySQL and PostgreSQL dialects, and its pricing model makes cost harder to cost. Additionally, it isn't ever free, even with AWS free tier. This is a decent source, but can be hard to understand for those unfamiliar with the industry.

[What is NoSQL? | Nonrelational Databases, Flexible Schema Data Models | AWS (amazon.com)](https://aws.amazon.com/nosql/)

AWS has several services to support alternate database paradigms. It touts high-performance NoSQL databases, enabling developers to leverage data that benefits from a NoSQL data model. Key services include Neptune and DynamoDB. This is a high-quality source.

[AWS Serverless Application Model - Amazon Web Services](https://aws.amazon.com/serverless/sam/)

AWS provides serverless functions and is a powerful tool for developing serverless applications. AWS Serverless Application Model (SAM) is a complete framework for modeling applications that run on serverless infrastructure. This includes local development and debugging, a supported IDE (Cloud9), Continuous Integration and Continuous Deployment, and an open-source community. This is a high-quality source.

[Cloud Storage on AWS (amazon.com)](https://aws.amazon.com/products/storage/)

AWS provides many cloud storage services. These include migrations, file and object storage, and backup services. S3 is a simple and popular way of storing objects, such as icons. This is a high-quality source.

**Microsoft Azure**

[Azure Containers—Services and Management | Microsoft Azure](https://azure.microsoft.com/en-us/product-categories/containers/)

Microsoft Azure provides an excellent table describing each container service's use cases. It includes managed container orchestration services such as Azure Kubernetes Service and Azure Red Hat OpenShift, serverless cloud functions with Azure Functions, and various deployment methods. Azure is notable for its descriptive naming of services. This is a high-quality source.

[Azure Cosmos DB – NoSQL Database | Microsoft Azure](https://azure.microsoft.com/en-us/services/cosmos-db/#documentation)

Cosmos DB is Azure's flagship NoSQL database service. They integrate several NoSQL APIs to be as developer-friendly as possible. It also touts high performance and virtually unlimited storage (if you've got the funds). They also extensively advertise their free features. This is a high-quality source.

[Azure Cloud Storage Solutions and Services | Microsoft Azure](https://azure.microsoft.com/en-us/product-categories/storage/)

This resource is an excellent table describing use cases for various Azure storage solutions. These include Azure Disk, Blob, Data Lake, Files, NetApp, Box, and secure Ledger solutions. Blob storage is notable as it integrates analytics, machine learning, and archiving. It's their flagship data storage product. This is a high-quality source.

[Azure SQL | Microsoft Azure](https://azure.microsoft.com/en-us/products/azure-sql/)

Azure SQL is the suite of SQL products and services offered. It includes migrations, managed database instances, or fully customizable database VMs. Azure supports SQL Server, MariaDB, MySQL, and PostgreSQL for SQL databases. \*Note that there are no Azure "Custom" databases, like AWS Aurora. This is a high-quality source.

[Azure Serverless | Microsoft Azure](https://azure.microsoft.com/en-us/solutions/serverless/#solutions)

Azure provides serverless services in several domains, from functions, serverless apps, AI and machine learning, databases, storage, monitoring, and analytics. They make it possible for a completely serverless architecture built on Azure infrastructure. They also include developer tools for serverless environments. This is a high-quality source.

**Google Cloud Platform (GCP)**

[Top 3 ways to run your containers on Google Cloud - YouTube](https://www.youtube.com/watch?v=jh0fPT-AWwM)

GCP provides three primary ways of deploying containers to the cloud. These include Google Kubernetes Engine for managed Kubernetes, Cloud Run for serverless containers, and compute engines optimized for running containers. These three simple options provide a wide range of flexibility. CI/CD is easy to set up through Google Container Registry. GCP even has a button to deploy containers from the registry using these three options. Additionally, GCP offers Anthos, a container cluster orchestrator that works in a hybrid-cloud environment. This is a high-quality source.

[Cloud SQL for PostgreSQL, MySQL, and SQL Server](https://cloud.google.com/sql)

Google advertises that Gartner named them an industry leader for cloud database management systems. They support managed MySQL, PostgreSQL, and SQL Server engines. Additionally, GCP databases easily integrate with other GCP services. This is a high-quality source.

[Datastore  |  Google Cloud](https://cloud.google.com/datastore), [Firestore: NoSQL document database  |  Google Cloud](https://cloud.google.com/firestore)

Datastore is GCP’s flagship product for NoSQL databases. They advertise SQL-like queries, indices, and even ACID transactions in a NoSQL context. Building on this, GCP built Firestore, a serverless document database. Firestore is also paired up with software developer kits in the most popular languages. This is a high-quality source.

[Cloud Storage  |  Google Cloud](https://cloud.google.com/storage)

GCP provides a several versions of storage, including “hot storage” that often serve data to applications and then varying degrees of archiving. This is a high-quality source.

[Serverless Computing Solutions  |  Google Cloud](https://cloud.google.com/serverless)

GCP provides serverless for running web applications, containerized applications, and functions. They advertise that it is incredibly fast, simpler for developers, and automated. This is a high-quality source.

**Firebase**

[Firebase Products (google.com)](https://firebase.google.com/products-build)

Firebase offers three main categories of products: Build, Release & Monitor, and Engage.

Build: Provides fully managed backend services that scale automatically.

Release & Monitor: Managed CI/CD pipelines, testing, application insights, troubleshooting, App hosting, release, and distribution.

Engage: Analytics, Predictions (ML), Auth, Messaging, A/B Testing, User Experience.

This is a decent source. It gives an overview of services provided, but not necessarily how they’re used.

[Firebase ML | Machine learning for mobile developers (google.com)](https://firebase.google.com/products/ml)

Firebase has several solutions for deploying machine learning models. They have prebuilt models for common use cases, such as text recognition, image labeling, and recognizing landmarks. You can train your own models and deploy them individually on user’s devices (client-side ML). This page is targeted toward mobile developers. This is a high-quality source.

[Cloud Functions for Firebase | Run your mobile backend code without managing servers (google.com)](https://firebase.google.com/products/functions)

Firebase allows writing serverless cloud functions in JavaScript (or TypeScript). It’s a fully managed function that can called or triggered many ways. They emphasize that functions integrate well anywhere, but especially with other Firebase products. This is a high-quality source.

[Firebase Products (google.com)](https://firebase.google.com/products-build)

All necessary services are listed on this page for developing and deploying the backend of applications, include several options for NoSQL databases, a fully managed identity provider, cloud functions, machine learning, remote config for production scenarios, cloud messaging, and cloud storage. This is a high-quality source.

[Cloud Storage for Firebase  |  Firebase Documentation (google.com)](https://firebase.google.com/docs/storage)

Fully managed content storage, advertised mostly for user generated videos, images, and audio. Works with mobile and web apps. Emphasizes that file transferring is robust, able to pause and resume file uploads and downloads on unreliable connections. This is a high-quality source.

**IBM Cloud**

[Containers on IBM Cloud | IBM](https://www.ibm.com/cloud/containers)

IBM provides five ways to run containers on their platform. This includes Cloud Kubernetes Service, managed OpenShift, Cloud Code Engine, Istio for microservices, Knative, and Cloud Foundry. This is a high-quality source.

[AI solutions on IBM Cloud | IBM](https://www.ibm.com/cloud/ai)

IBM provides an entire ecosystem of fully managed AI solutions tailored for specific uses. It targets many industries, such as IT, customer service, finance, healthcare, and more. This is a high-quality source.

[Cloud Databases on IBM Cloud | IBM](https://www.ibm.com/cloud/databases)

IBM sections off their database services by use case, including standard MySQL and PostgreSQL clusters. IBM Db2 is their own proprietary SQL engine implementation that’s advertised as “enterprise-class.” They offer Json-based NoSQL stores and managed caching. Finally, there are solutions for secure storage and data warehousing. This is a high-quality source.

[What is Serverless Computing? | IBM](https://www.ibm.com/cloud/learn/serverless)

An excellent rundown on the pros and cons of serverless development. Serverless should be used for spiky workloads, not steady, predictable ones. They explain that it simplifies DevOps by abstracting away the infrastructure. This is a high-quality source.

Part 2: Cloud Provider Summaries

**Amazon Web Services**

This provider is an absolute monster in the cloud industry, having grown tremendously since 2006. With over 200 services with varying degrees of management and an infinite number of applications, AWS remains comprehensive. Once could write a four-hundred-page report on AWS alone that would still not cover everything. AWS attempts to document how to do most things on their platform, but it is not intuitive. It is difficult to understand for those who aren’t incredibly experienced in computer networking, cybersecurity, computer architecture, and other niche computer topics. Additionally, the dizzying number of products can make it hard for developers and architects to understand the ecosystem and make educated decisions on the infrastructure they want to use.

AWS provides, of course, the basics necessary for application development. App hosting, computing power, database and storage solutions are all supported. There is also excellent tooling and infrastructure for serverless development, allowing teams to focus more on development and less on infrastructure. There is a wide offering of database engines of varying paradigms and storage types, including the AWS proprietary Aurora RDMS that’s touted to be far more efficient. The support for docker container deployment is incredible, with over 10 practical ways of deploying containers and two extremely power tools. These deployment options range from fully managed, to fully configurable, bare-metal servers. Unfortunately, some services are incredibly similar, which doesn’t with the confusion. AWS is an excellent option for application development if you don’t get lost.

**Microsoft Azure**

Fun fact: Iowa State is currently migrating to Iowa State. Our development and production servers, at least for my department, are on azure servers now. First released in 2010, Azure now provides over 200 cloud products. Azure has excellent documentation that goes beyond text walls. They utilize many more eye-friendly diagrams and tables that break down concepts, key information, and differences in a way that’s easier to ingest. Additionally, services are adequately named after their function (App Service, Functions, Azure SQL, for example). From HR point of view, Azure is an excellent choice in reducing man hours and preserving IT sanity. While the sane naming convention improves usability, there are still many products to choose from. Azure remains a conglomerate of confusing and often too-similar services, contributing to IT mess. It would take a massive effort to remain organized.

Azure provides very clear storage options, ranging from “hot” storage to very deep archive storage. Azure also provides a suite of SQL services designed to work well together. DB options include Azure’s proprietary CosmosDB for NoSQL, managed MongoDB, and classic SQL enginges such as PostgreSQL, MySQL, and MS SQL.

Azure often provides serverless alternatives to their popular products, such as database and app hosting. In addition to Azure cloud functions, there are also serverless function apps, designed to organize functions into event-driven applications. There is excellent tooling and SDKs to support these design patterns on Azure.

**Google Cloud Platform**

The world knows google well for their incredible search engine and extremely efficient algorithms for data processing. Google’s cloud service, GCP, embodies this by emphasizing their data science products, such as machine learning, AI, and Google Analytics. This makes sense since Google is world-renown for their analytics and data engineering. Among academics and data science professionals, GCP seems to be the most popular. Thanks to Google’s Material Design principles, their UIX is incredible, reducing headaches and preserving IT professionals’ sanity.

Google, as the original creator of the Kubernetes project, has some of the most intuitive managed Kubernetes services and great overall support for docker containers, a key component in application development. Additionally, Google has a remarkable product called Anthos, a cloud cluster orchestrator that works in distributed, on-prem, and hybrid deployments.

**Firebase**

Firebase is a Backend as a Service (BaaS) that is built on top of Google Cloud Platform. It provides a number of limited, but extremely power products. They have two premier database services, known as Firestore and Realtime store. Both are NoSQL, optimized for different use cases. However, Firebase has tried to advertise Firestore as the next generation of Realtime.

Mobile development is the name of the game, as nearly every page on the Firebase website has some mention of mobile development. Other managed services include but are not limited to cloud functions, an identity provider with several sign in options, machine learning, chat systems, application insights and analytics, and even A/B testing.

**IBM Cloud**

IBM cloud provides basic services like compute, but notable with a different pricing model. For example, compute only provides powerful dedicated instances at high monthly rates. IBM does not seem to be as startup friendly, as they offer massive enterprise solutions for application development. Their featured services are managed Kubernetes, OpenShift, and other managed containerized and distributed application software.

IBM clearly recognizes that they lack much of what its competitors have. In response, they have developed many hybrid cloud solutions for managing applications, workflows, and communication between major cloud providers. They even have IBM extra-managed databases hosted off of AWS and Azure, which are already managed. However, they do have a commitment to serverless services, which may mark them as a future leader in infrastructure-free development.

Although IBM does not lead in IaaS or PaaS, they have a lot of SaaS offerings. They have developed many AI services for very specific use cases in industries such as IT, customer service, finance, healthcare, and more. I’m tired.

Part 3: Cloud Provider Comparisons

**Popularity**

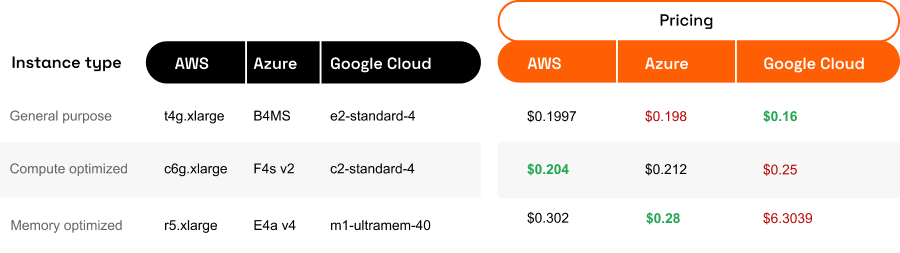
Azure leads the cloud market with 32% of the market share in [Q1 of 2021](https://www.wpoven.com/blog/cloud-market-share/), followed by 20% of Azure and 9% for Google Cloud. IBM floats at 5%. Firebase is not listed because they are not a traditional cloud provider and is an extension of GCP.

**Offerings**

Both AWS and Azure have similar offerings of over 200 services, but AWS leads in maturity and extra features. Google Cloud offers core components necessary for application development and hosting along with basics such as compute, storage, and database. GCP differs in that they put a massive emphasis on data science applications, such as machine learning, analytics, and batch data jobs. IBM offers core services necessary for application development along with the fundamentals as well. However, they also have more industry specific SaaS, along with hybrid cloud solutions. IBM is trying to ride the success of other providers instead of fully competing within the market.

**Cost**

Compute pricing is a good benchmark for comparing costs between providers. In 2021, a Cast.ai blog post provided an excellent graphic for comparing compute costs in several configurations.



Note that for general purpose, GCP surprisingly has the cheapest pricing at $0.16 per hour, whereas AWS and Azure are comparable. The story changes for compute and memory optimized, with google trailing behind their competitors. IBM does not have a comparable pricing model, as they charge large monthly amounts for dedicated instances that are comparable to everyday laptops. Firebase does not provide compute services, as their products are ultimately built on GCP infrastructure.