Solar analytics using AWS serverless services

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2 authors:

Shreyas Hole
VIT-AP

Agam Goswami
National Institute of Technology Rourkela

Chapter 1

Solar analytics using AWS serverless services

Shreyas Rajendra Hole and Agam Das Goswami
VIT-AP University, Amravati, Andhra Pradesh, India

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1.1 INTRODUCTION

The magnificent and limitless amount of pure, renewable energy provided by the sun may be enjoyed by all of the world's people. As a matter of fact, in a single hour, our planet absorbs more solar energy than the whole globe uses in a year. Solar photovoltaic (PV) modules (photo = light, voltaic = electricity) have the potential to convert the energy emitted by the sun into electrical current.

In general, solar technology may be divided into the following types: Photovoltaic (PV) systems, concentrated solar electricity, and solar water heating are all examples of active solar approaches. The drying of garments and warming of the air are two examples of active solar power in action. A few examples of passive solar approaches include utilizing solar orientation, high thermal mass or light-dispersing materials, and design features that promote natural airflow into a structure.

Over the course of a month, the world's supply of fossil fuels is about equal to the quantity of solar energy that arrives on Earth. As a result, solar

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energy has a worldwide potential that is many folds more than the total energy required of the whole globe at the moment. There are a number of technical and economic challenges to overcome before widespread use of solar energy is even considered. It will be our capacity to overcome scientific and technical hurdles, together with marketing and financial issues, along with political and regulatory considerations, such as renewable energy tariffs, that will define the future of solar power installations.

1.1.1 Solar thermal power

Photovoltaics (PV), concentrated solar power (CSP), and both are all types of solar power that use the sun's free energy to make electricity. Concentrated solar power systems use lenses or mirrors and solar tracking technology to focus sunlight into a small beam that can be used for electricity. The photovoltaic effect is used in solar cells to turn light energy into electricity [1].

A single solar cell-powered calculator or an off-grid rooftop PV installation may power a remote dwelling. Photovoltaics, on the other hand, have largely been utilized as a power source for small and applications with a medium-sized scope up until recently. In the 1980s, CSP plants became financially feasible. In recent years, as the price of solar electricity has reduced, the number of grid-connected solar PV systems has risen exponentially. Gigawatt-scale solar power plants and millions of smaller ones have been constructed. It has become a low-cost, low-carbon technology in recent years. IEA's "Net Zero by 2050" scenario forecasts that solar power will contribute around 20 percent of global energy consumption by 2050, making it the biggest source of electricity in the world.

In terms of solar installations, China has the most. In 2020, solar power will account for 3.5% of global energy production, up from less than 3% in the previous year. Utilities could anticipate to spend around $36/MWh for utility-scale solar power in 2020 [2], with installation costing about one dollar per DC watt [3].

Several rich nations have incorporated huge volumes of solar energy capacity into their power systems in order to add to or substitute for existing energy resources. Meanwhile, developing nations are increasingly turning to solar energy to reduce their reliance on expensive imported fuels and to reduce their carbon footprint. The utilization of long-distance transmission allows for the replacement of fossil fuels with renewable energy resources located a great distance away. Solar power plants employ one of two techniques to generate electricity. First is Photovoltaic (PV) systems, whether mounted on a roof or installed on the ground, capture and convert sunlight directly into power. Second is Concentrated solar power (CSP) facilities create electricity by using solar heat to generate steam, which is then pushed via a turbine to generate electricity.

1.2 RELATED WORK

In order to increase the usage and expansion of thermal energy in an ecologically sustainable manner, weather conditions are forecast, enhancing the efficiency and consistency of energy distribution over the long term [5]. Maintenance of solar power plants is carried out via the execution of operations and maintenance (O&M) activities that make use of predictive analytics, supervisory control, and data collection in order to boost and improve performance (SCADA). The utilization of the internet (cloud) and Internet of Things (IoT) devices, as well as operations and maintenance, supervisory control, and data acquisition, may improve preventive maintenance. There is a considerable increase in the efficiency of solar power plants in India as a result of efforts by a variety of various industries across the nation. The goal of this article is to increase the efficiency of solar power plants via the use of the IoT and predictive analytics.

The authors of a research paper employed three free datasets given by National Institutions to investigate historical trends and policy alternatives for soil usage and power consumption, as well as to evaluate correlations between these variables [7]. It was decided to undertake the analysis on a provincial level. Thereafter it was concluded that the deviations from the policy scenarios needed to be addressed in order to emphasize the need for policy ideas and pathways to achieve the goal of a renewable energy share and a decrease in SO_2 consumption trends by 2030. For example, because of its position in the field of renewable energy integration, building integrated photovoltaics (BIPV) is considered to be a critical driver in the solution of this issue.

Photovoltaic (PV) systems and electrical energy storage (EES) for PV systems are both explored in length in a research paper [8]. Cellular technologies of the future are examined. The study also involves a look at solar power forecasting methodologies for PV and EES operation and planning. Sizing PV and energy storage systems with anaerobic digestion biogas power plant (AD) is established in order to avoid energy imbalance between production and demand due to AD generator limits as well as high penetration of photovoltaic (PV) panels. Correlation analysis in machine learning faces challenges from uneven data and data uncertainty. With the support of extensive assessments of real solar irradiance and meteorological condition data, a prospective framework has been built and tested. To construct the clearness index (CI), a cluster analysis utilizing Fuzzy C-Means with dynamic temporal warping and other methodologies is done on real-life solar data.

The quantity of solar radiation that enters the building has a considerable impact on the design of solar architecture. It is the building envelope that is most important when it comes to solar heat and light transmission since it determines how well the structure performs [9]. In the development of solar architecture, the use of computer modeling and simulation is essential. When doing this kind of computer analysis, it is common to utilize a year's worth of weather data that has been saved in a typical weather file. The total of ultraviolet, visible, and near-infrared (UV, VIS, and NIR) light is used in typical solar architecture design analytics; nevertheless, these three components play distinct roles in a building's energy efficiency. It may be beneficial to analyze the different solar modules in isolation from one another. With the use of freely available information from ground weather stations, models for the estimation of visible and near-infrared components will be created that can be easily integrated into current available solar architecture design and topics of research activities. The classification-based modeling techniques were used to examine and assess the decomposition of hourly worldwide horizontal solar VIS and NIR components from traditional weather files into hourly global horizontal solar VIS and NIR components from traditional weather files. An established technique for using these models for solar architecture design and analysis has been developed, which is described in detail in the research article [9].

Another investigation with a purpose to find out Uttarakhand's solar potential in the cloud using Perl and Geographic Information Systems (GIS) [10]. The Citrix XenCenter hypervisor, which is a bare-metal hypervisor, was used to develop the cloud computing environment. According to Pyranometer and the National Renewable Energy Laboratory website, some GHI data has been collected. The GHI of the sloped surface was transformed using Perl programming in order to guarantee that the solar PV got the maximum amount of solar irradiation feasible for its size. These solar resource maps may be useful for a variety of purposes, including PV installations, resource planning, solar savings, energy trading, and subsidies. From people to organizations and the federal government, they are all accessible.

By constructing solar power plants, one may alter the landscape in a positive way. This landscape alteration has sparked concerns about the aesthetic impact, land-use competition, and the end-of-life stage of solar power facilities, among other things. Existing research [11] advises connecting solar power plants with their surrounding landscapes, a concept known as the solar landscape, in order to address these challenges. The goal of solar landscapes is to give a variety of benefits in addition to electricity generation, such as decreasing visibility and establishing habitats, however there is a paucity of scientific study on solar landscapes today. It is our aim that this comparative analysis of 11 prominent occurrences will assist us in better understanding solar landscapes by assessing their visibility (as well as their multifunctionality and temporality). Every situation results in lowered sight. However, there are five occasions in which recreational facilities may assist in increasing visibility. The cases performed between six and fourteen roles in terms of providing, regulating, and cultural expression. Functions might be found in arrays, between arrays, and in the vicinity of solar patches. The majority of the time, concerns about the future use of the sites were raised, but only in two cases were new landscape components introduced to encourage the future use of the areas. The other issues were addressed in other ways. In this case study [11], many concerns, such as the aesthetic impact, land-use competition, and the end-of-life stage, are explored in further detail. Taking them all together, they provide a diverse variety of approaches to addressing societal concerns, but the full potential of three crucial characteristics has yet to be realized. This comparative research also demonstrates the need of addressing the development of trade-offs between spatial elements as well as the necessity to discriminate between different types of solar landscapes. Using the analytical technique that has been developed, it is feasible to analyze both the good and negative features of solar power installations.

It has been proposed in a study to simulate the solar power generating system in Medellín, Colombia, with the use of ML technologies [12]. There are four forecasting models that have been created utilizing approaches that are compatible with ML and AI technologies. They are the K-Nearest Neighbor (KNN), Linear Regression (LR), Artificial Neural Networks (ANN), and Support Vector Machines (SVM) (SVM). The accuracy of the four techniques utilized to estimate solar energy output was determined to be high. The ANN forecasting model, on the other hand, delivers the best accurate prediction, according to the RMSE and MAE. Medellín's PV power production was predicted using ML models, and it was discovered that these models were both possible and successful.

1.3 INTERNET OF THINGS (IOT)

The IoT allows objects that have electronics incorporated into their design to communicate and experience interactions with one another and with the outside world via the use of wireless technology (IoT). During the next several years, the IoT has the potential to completely transform the way individuals go about their daily lives. The IoT has achieved important advances in a variety of disciplines, including medicine, energy, gene therapy, agriculture, smart cities, and smart homes, among others [13]. It is estimated that more than 9 billion "Things" (physical goods) are now available for purchase on the internet. In the not-too-distant future, this number is expected to soar to an astounding 20 billion individuals. Figure 1.1. shows an IoT based solar monitoring system.

For IoT, there are four primary components:

1. Embedded systems with low power consumption.
2. Computing in the cloud.
3. Readily available big data.
4. A link to the internet.

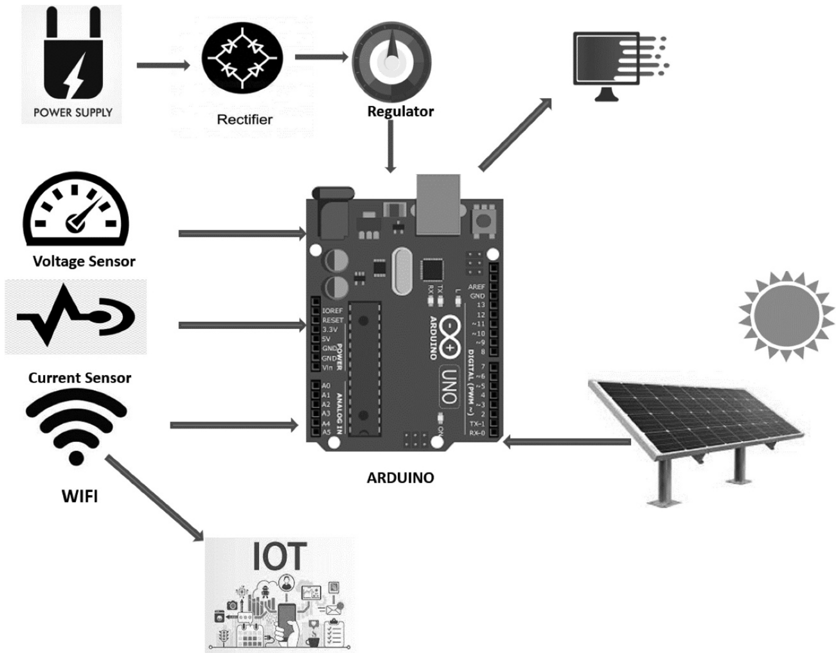

Figure 1.1 Solar energy monitoring system powered by IoT.

As a consequence of the Internet of Things' rising bandwidth and lowering hardware prices, the surroundings of many industries are rapidly changing. There are several new applications for the IoT being developed in a variety of industries such as healthcare, construction, as well as government and insurance. As a consequence of these advancements, large corporations, financial institutions, and other organizations are all increasing their investment on information technology.

The Industrial IoT includes a wide range of device, application, and engineering systems, but they all have the same fundamental components. IoT architecture is explained in Figure 1.2.

- **Smart gadgets and sensors**
  The top layer of the protocol stack consists of connections between devices and sensors. The smart sensors are continually collecting and transmitting data from their immediate surroundings, which they refer to as the immediate environment. It is now feasible to manufacture tiny smart sensors for a broad variety of different applications by using the most up-to-date semiconductor technology available on the market.

  First and foremost, information about their immediate surroundings is obtained by sensors and devices that might vary from a simple temperature measurement to a full live video stream. The phrase "sensor/

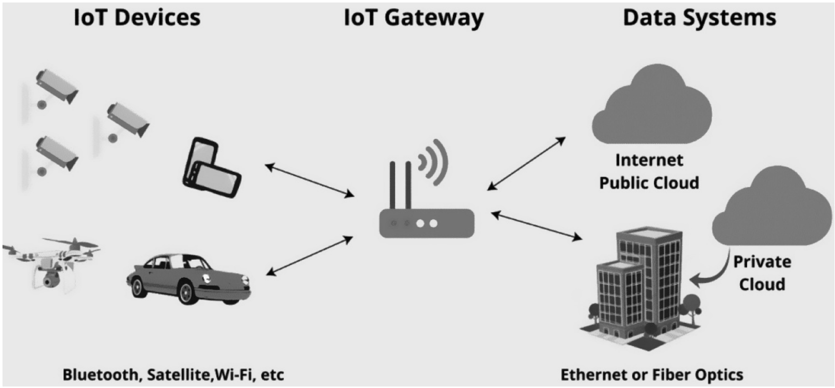

Figure 1.2 Architecture of IoT.

device" may be used to describe a sensor that is a component of a larger gadget that performs functions other than just sensing the surrounding environment. When it comes to sensors (such as a camera and an accelerometer), phones are more than just sensors, since they are capable of performing a broad range of functions with their sensors.

It is necessary to set up a cloud service in order for data to be transferred. Connecting sensors and devices to the cloud may be accomplished via the use of cellular, satellite, Wi-Fi, Bluetooth, low-power wide area networks (LPWAN), a gateway, or a router. Considering power usage, range, and bandwidth are all important considerations when making a selection. Connection choices for IoT applications are many, but all are aimed on transmitting data to a cloud service.

- **Gateway**
  The IoT Gateway is responsible for coordinating bidirectional data flow across a variety of networks and protocols. Gateways are devices that translate between different network protocols in order to guarantee that linked devices and sensors are compatible with one another. Pre-processing of data gathered from hundreds of sensors may be conducted locally by gateways before it is forwarded to the next level. Because of the compatibility of the TCP/IP protocol, it may be necessary in particular situations. Higher-order encryption algorithms, when used in conjunction with IoT gateways, provide a certain level of security for the network as well as the data that is sent over the network, according to the FBI. It protects the system against damaging assaults and unauthorized access by acting as an intermediary layer between the cloud and the devices.
- **Cloud**
  Devices, applications, and users connected to the IoT will create tremendous volumes of data, and managing this data will be a significant issue. On real time, data can be collected and analyzed, while also

being managed and saved in the cloud, due to the IoT. Businesses and services may have access to this information from a distance, enabling them to make critical decisions when the situation calls for it. IoT platforms are complicated, high-performance networks of computers that can analyze billions of devices, manage traffic, and give accurate insights in a short period of time. They are becoming more popular. Distributed database management systems (DBMS) are an essential component of the Internet of Things cloud (DBMSs). The ability to store data and do predictive analytics is made possible by a cloud architecture that links billions of connected devices. Businesses use this information to improve the quality of their products and services, to prevent issues from developing, and to better develop their new business model based on the information they have accumulated.

1.4 THE USE OF CONTEMPORARY TECHNOLOGIES IN SYSTEM DESIGN

Time and technology improvements have resulted in a rush of new tools during the previous decade. These instruments have a positive impact on systems and processes. Some of the areas and technologies that may be employed to increase performance are mentioned below. Figure 1.3 displays the most frequent new system design tools. It highlights the interconnectedness between AI, ML, and DL. When it comes to artificial intelligence (AI), machine learning (ML) is the subset and when we discuss ML, Deep Learning (DL) is a subset to ML.

- **Artificial Intelligence**
  It is a wide topic in the study of artificial intelligence (AI), which is divided into many subfields, that computers' ability to develop logical

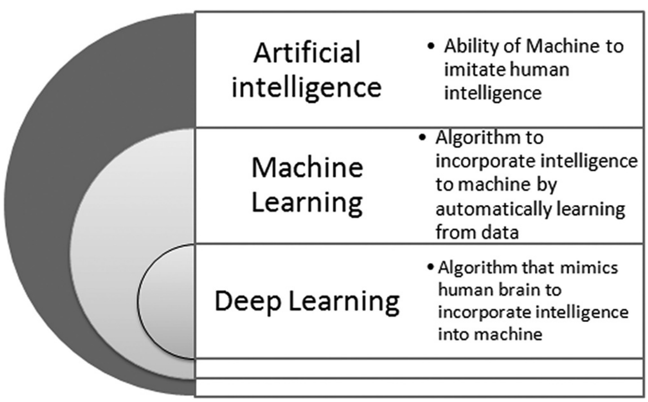

Figure 1.3 Relationship between AI, ML, DL.

behavior in response to external inputs is a broad issue in AI. The ultimate goal of artificial intelligence will be the development of systems that can do tasks that would otherwise need human intelligence. There are many different perspectives on AI and how it relates to the products and services that we use on a daily basis. One of the project's objectives is to develop expert systems that can learn from their users, exhibit their capabilities, explain their capabilities, and give advice. The ultimate goal of infusing human intelligence into robots is to create machines that are capable of comprehending, reasoning, and learning in the same way that humans are capable of doing these things. Figures 1.4 and 1.5 demonstrates a broad spectrum of artificial intelligence applications (AI). Figure 1.4 describes types of AI on the basis of technology, whereas Figure 1.5 focuses on types of AI on the basis of functionality.

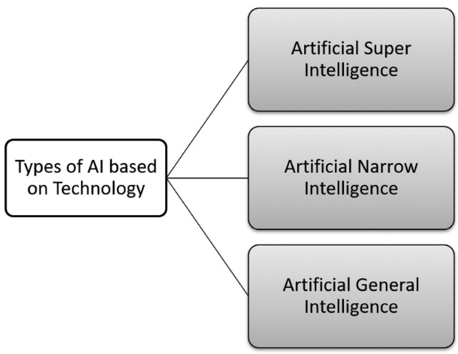

Figure 1.4 AI classification on the basis of technology.

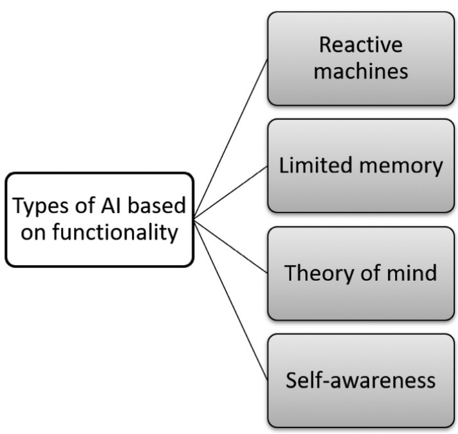

Figure 1.5 AI classification on the basis of functionality.

In recent years, as machine learning has advanced during the preceding two decades, there has been an increase in interest in AI. It has become more popular in the twenty-first century to use artificial intelligence in many applications (AI). Consequently, ML may be utilized to construct systems that are always improving.

- **Machine Learning**
  Computers perform algorithm-based procedures, which means there is no space for mistake in their results. Data from current samples may be utilized in place of written instructions that produce a response based on the data provided, enabling computers to make decisions based on the data. Computers, like people, have the capacity to make mistakes when making judgments, and this is no exception. As a result, it is a kind of ML in which computers can learn in the same way that people do, by using data and previous experiences [26]. One of the fundamental goals of ML is to develop prototypes that can self-improve, recognize patterns, and propose answers to new problems based on the data they have collected in the past. Figure 1.6 explains the types of ML. ML may be broken down into five categories:
  1. Supervised learning.
  2. Unsupervised learning.
  3. Semi-supervised learning.
  4. Reinforced learning.
  5. Deep learning.
- **Supervised learning**
  A dataset containing some observations and their labels/classes must exist for this family of models in order for them to be used. For example In order to perform observations, it may be necessary to utilize species photos, with the labels identifying each animal by its scientific name.

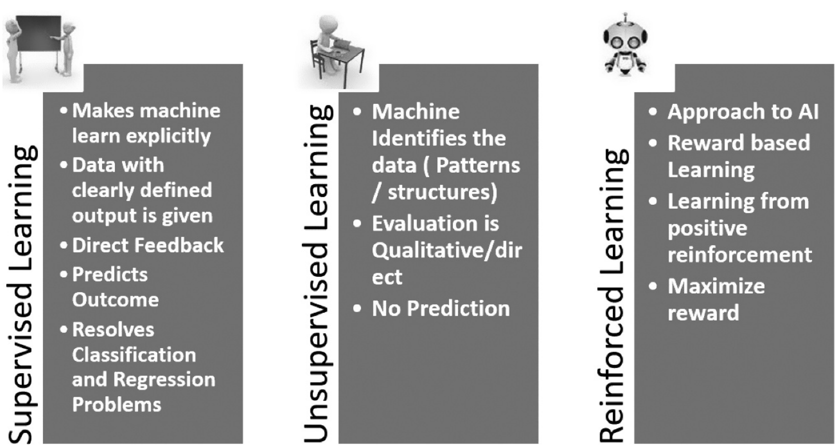

Figure 1.6 Types of machine learning.

First and foremost, these models must be trained by learning from the labeled datasets before they can make predictions about the future. Whenever new, unlabeled data are added to the model, the learning algorithm makes use of the inferred function that it has created in order to anticipate what will happen when the new observations are received. In the wake of proper training, a model is capable of generating goals for each new data it encounters. Additionally, the learning algorithm may detect errors by comparing its output to the intended output (the ground truth label) and changing its output as required to get the desired result (e.g., via back-propagation). Regression modeling and classification modeling are the two types of supervised modeling approaches. In the former, we make predictions or draw conclusions based on the facts already available. In the latter, an analysis method known as categorization divides large datasets into smaller subsets based on common characteristics is used.

- **Unsupervised learning**
  It is necessary to have some data in order to make use of this family of models; however, it is not necessary to know the labels or classifications of the data in advance. If a system intends to infer a function from unlabeled data, the data must first be labeled in order to explain a hidden structure that has been discovered. In unlabeled data, hidden structures may be defined by employing a data exploration technique and inferences derived from datasets, and a system can make use of data exploration and inferences made from datasets in order to do this.
- **Semi-supervised learning**
  This topic is conveniently located in the midst of both the supervised and unsupervised learning groups, making it simple to cover all of the material. Semi-supervised models learn on data that is both labeled and unlabeled, and this data is used throughout the training phase. In situations when the quantity of labeled data is less than the amount of unlabeled data, both unsupervised and supervised learning are rendered worthless. Many instances exist in which material that has not been properly categorized is exploited to make generalizations about persons without their knowledge. This strategy is referred described as "semi-supervised learning" in generic terms, although it is more specific. Semi-supervised learning, as opposed to unsupervised learning, makes use of a labeled data set rather than a randomly produced data set. Similarly to supervised learning, the labeled data contains more information than the data that must be predicted. This type of learning makes use of smaller labeled datasets than projected datasets, which makes it more efficient.
- **Reinforced learning**
  These algorithms utilize estimated mistakes as incentives or penalties in order to reward or penalize its users. Those found guilty of a

significant mistake face severe penalties and get little compensation. There will be no harsh penalties or significant rewards if the fault is minor.

- **Deep learning**
  It is the only kind of machine learning that focuses on training the computer to replicate human behavior, which is known as deep learning. Deep learning is the process through which a computer system learns to identify complicated information, such as photographs, text, or speech, via trial and error. For example, this method may be able to attain accuracy levels comparable to those of the current state of the art (SOTA). In certain circumstances, it may even exceed humans in terms of performance. They must be trained using a large quantity of labeled data and neural network topologies with several layers in combination, both of which are time-consuming. DL has the following noteworthy characteristics:
  - Developing technology such as virtual assistants, facial recognition, driverless cars, and other comparable technologies relies heavily on Deep Learning.
  - It begins with the collection of training data and ends with the use of the training's outputs.
  - To describe the learning technique, the term "deep learning" has been adopted since the neural networks quickly learn about new layers of data that have been introduced to the dataset over the course of a few minutes. To improve the system as a whole, all training is done with the goal of making it more efficient.
  - It has been widely accepted as a training and deep learning system by data experts, which has resulted in a significant increase in training efficiency and power.

1.5 SERVERLESS SOLAR DATA ANALYTICS

There are a variety of smart devices and sensors that can be used to create raw data, which can then be analyzed in more detail using analytics software. Smart analytics solutions are required for the administration and optimization of IoT systems. When an IoT system is correctly built and implemented, it is feasible for engineers to discover irregularities in the data gathered by the system in real time and to take quick action in order to avoid a negative consequence that may have occurred otherwise. If the data is gathered in the proper manner and at the appropriate time, service providers will be able to prepare for the next step. Large corporations are taking use of the massive volumes of data created by IoT devices in order to get fresh insights and open up new business opportunities. It is feasible to foresee market trends and prepare for a successful implementation via the careful use of market research and analytical techniques. Predictive analysis, which is a key component of every business model, has the potential to significantly improve a company's capacity to perform in its most vital areas of business.

We will make use of Amazon Web service (AWS), a well-known cloud service provider, in order to complete data analytics serverless. The architecture used to obtain the analytics is depicted in Figure 1.7. Assume we have an N-number of Internet-of-Things devices/sensors that are broadcasting the intensity of sunlight to the cloud in real time. The rest of the analytics will be handled by this architecture, which will be serverless in nature.

- **Kinesis Data Streams**
  Amazon Kinesis Data Streams is a streaming data service that is completely controlled by Amazon. In addition to click streams and application logs, Kinesis streams may receive data from hundreds of thousands of sources at any same time [27]. Kinesis Applications will be able to access the data in the stream and begin processing it within a few seconds of the stream being created. Amazon Kinesis Data Streams takes care of all of the Hardware, memory, connection, and configuration concerns necessary to stream your data at the pace you choose. Everything from provisioning to deployment to ongoing maintenance and other services for your data streams is handled on your behalf. The synchronous replication of data across three AWS Regions provided by Amazon Kinesis Data Streams ensures high availability and long-term data durability.

  We may begin utilizing Kinesis Streams after signing up for Amazon Web Services by following these steps:
  1. Create a Kinesis stream; this can be done through either Management Console or CreateStream operation.
  2. Constantly generating new data from our data generators.
  3. Using the Kinesis Data Streams API or the Kinesis Client Library stream (KCL), we may create Kinesis applications that read and process data.
- **Kinesis Data Firehose**
  Amazon Kinesis Data Firehose is the most efficient method of transferring streaming data into data repositories and analytics tools, according to the company. As a streaming data storage service, Amazon S3 may be used to collect, transform, and store data streams, which can then be analyzed in near-real time using the business intelligence tools and dashboards that we are currently familiar with. This is a fully managed service that adjusts automatically to the flow of our data and really doesn't need further management on our behalf [28]. It may also batch, compress, and encrypt the data before loading it, which decreases the size of storage space necessary at the destination while increasing security at the same time.

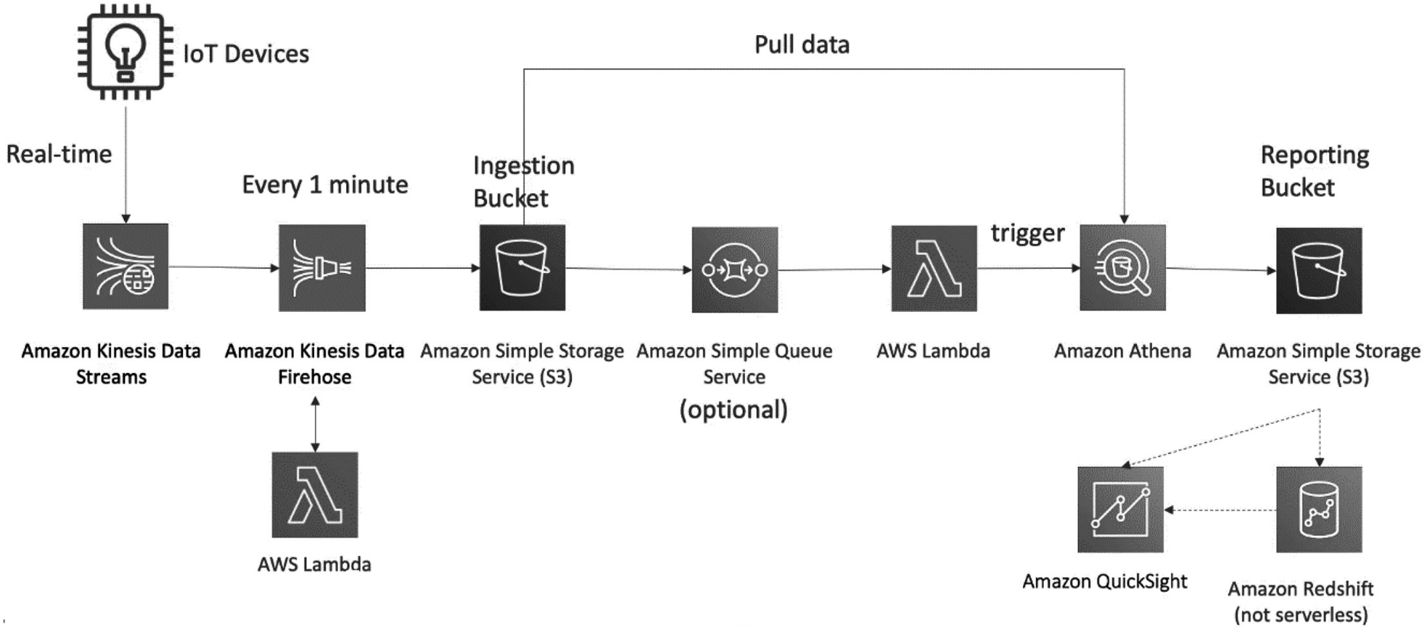

Figure 1.7 AWS severless data analytics solution for solar power.

Customers may gather and load their data into Amazon S3, Amazon Redshift, or Amazon Open Search Service using Amazon Kinesis Data Firehose without having to worry about any of the underlying infrastructure, storage, networking, or setup requirements. We don't have to worry about setting up hardware or software, or about building any new programs in order to keep track of this operation since it is automated. Firehose is likewise scalable, and it does so without the need for any developer engagement or overhead to be involved. This results in the synchronous replication of data across three Amazon Web Services regions, assuring high availability and durability of the data as it travels to its final destinations [31–35].

We may begin utilizing Kinesis firehose after signing up for Amazon Web Services by following the steps:

1. Use the Firehose Console or the Create Delivery Stream operation to create an Amazon Kinesis Data Firehose delivery stream. Optionally, we can set up our delivery stream to use an Amazon Lambda function to preprocess and alter the raw data before importing it.
2. Configure the data generators to send data to your delivery stream on a regular basis by utilizing the Amazon Kinesis Agent or the Firehose API to provide data to the delivery stream.
3. Firehose uploads the data in a continuous and automated manner to the destinations we choose.

- **Amazon S3**

"S3" stands for Simple Storage Service. In order to store and retrieve any amount of data from anywhere, Amazon S3 was designed as an object storage system. An easy-to-use, low-cost solution that enables industry-leading scalability at a fraction of the expense. Using the use of Amazon S3, users may store and access a limitless amount of data at any time and from any location, all through a simple web service interface. This service simplifies the process of developing cloud-native storage-aware applications [29]. One may start small and expand their application as they find appropriate, all while retaining uncompromised speed and reliability because of the scalability of Amazon S3 [36–41].

Furthermore, Amazon S3 is designed to be very versatile. Whether you wish to preserve a little amount of data for backup purposes or a huge amount for disaster recovery, anyone may do so using a simple FTP application or a complicated web platform such as Amazon.com. Amazon S3 relaxes developers from having to worry about where to store their data, allowing them to spend more time innovating.

With Amazon S3, users only pay for the amount of storage space that they consume. There is no predetermined pricing for this service. Your monthly expenditure may be estimated with the aid of the AWS Pricing Calculator. When our overhead is smaller, we may charge a lesser rate. Some items are priced differently in various Amazon S3 regions. The location of your S3 bucket has an impact on the cost of your monthly payment. No data transfer fees are charged for COPY requests that move data inside an Amazon S3 Region. Depending on which AWS region the data is being transmitted to, Amazon S3 charges a fee for each gigabyte of data that is carried across the service. Transferring data from one AWS service to another within the same geographical area, such as the US East (Northern Virginia) region, will not result in a data transfer fee being applied to the account.

The service is completely free, and there is no obligation to pay anything up front or make any commitments before beginning to use it. At the end of each month, users are invoiced for the amount of energy used during the previous month. Tap “Billing and Cost Management” under “Web Services Account” after logging into the Amazon Web Services account to get a list of current spending. We may get started with Amazon S3 for free by taking advantage of the AWS Free Usage Tier, which is available in all regions with the exception of the AWS GovCloud Regions. Furthermore, new AWS customers get 20,000 get requests and 2,000 put requests per month for the first year, as well as 15 GB of data transfer out of Amazon S3 during that time period. The amount of monthly use that is not utilized will not be carried over to the next month.

- **Amazon Athena**
  Amazon Athena is a data processing tool that simplifies the process of examining data stored in Amazon S3 using normal SQL queries. It is available for both Windows and Mac users. It is available for download and usage by users of both Windows and Linux operating systems. It is not necessary to set up or maintain any infrastructure since Athena is a serverless platform, and users may start analyzing data immediately after installing it. We don’t even have to input the data into Athena since it works directly with data stored on Amazon S3, so there’s no need to do so at all. Begin by login into the Athena Management Console and setting the schema that users will be using. After that, begin querying the data stored in the database by using the Athena API [30]. It is possible to use Athena as a database on the Presto platform, and it includes all of the usual SQL features. Other prominent data formats supported by the tool include Oracle Relational Catalog, Apache Parquet, and Avro. CSV and JSON are only two of the formats supported by the tool. Achieving complicated analysis, despite the fact that Amazon Athena is suitable for fast, ad hoc querying and that it integrates well with Amazon QuickSight for simple visualization, is possible with it. This includes huge joins as well as window functions and arrays, among other things.

  The Amazon Athena query service, the Amazon Redshift data warehouse, and the sophisticated data processing framework, the Amazon EMR, are all intended to suit a broad variety of data processing needs and use case situations, respectively. All that is necessary is that we choose the instrument that is best appropriate for the task at hand. AWS Redshift is the best choice for corporate reporting and business intelligence workloads when we need quick query performance for complicated SQL queries, which is exactly what we need. In addition, it is the most cost-effective option available. With Amazon EMR, it is simpler and less costly to manage widely dispersed processing frameworks like as Hadoop, Spark, and Presto, while also lowering the total cost of ownership. To meet analytic requirements, users may run bespoke apps and code on Amazon EMR. We can also customize particular CPU, memory, storage, and application characteristics to meet our needs. Amazon EMR is a service provided by Amazon. Using Amazon Athena to query data in S3 eliminates the need for any additional servers to be installed or maintained.

- **Amazon QuickSight**
  It is simple for everyone in your organization to get a better understanding of the data thanks to the interactive dashboards, machine learning-powered patterns, and outlier identification in Amazon QuickSight. A cloud-based business intelligence (BI) tool for large organizations. Using Amazon QuickSight, users can easily share insights with their team, no matter where they are located in the world. With Amazon QuickSight, customers can access and aggregate the cloud-based data in a single place. All of this information is accessible in a single QuickSight dashboard, which includes data from AWS, spreadsheets, SaaS, and business-to-business transactions (B2B). Amazon QuickSight is a cloud-based service that is totally managed and provides enterprise-grade security, global availability, and built-in redundancy. It is available on a subscription basis. One may also scale from 10 to 10,000 members using the user management features provided by this solution, all without the need to invest in or maintain any infrastructure.

  In order to better understand and digest data, QuickSight offers decision-makers with an interactive visual environment in which to do so. Dashboards may be viewed securely from any computer or mobile device connect to the network, including a smart phone.

- **Lambda**
  This service allows the user to access their code without the need to set up or maintain servers on own computer. When the code is not being executed, users are only charged for the compute time that was used. Lambda may be used to operate any and all of existing apps and backend services, with no need for further management. Lambda takes care of everything users need to run and expand the code with high availability, and we just need to submit the code once to take advantage of this. Our code may be activated on demand by an AWS service, a web page, or a mobile application, or we may call it directly.

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