Cloud Service Selection Using Machine Learning

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Abstract

Cloud computing (CC) has recently been receiving tremendous attention from the IT trade and educational researchers. CC leverages its distinctive services to cloud customers in a very pay-as-you-go, anytime and anyplace manner. As well as Cloud services offer dynamically scalable services on demand. Therefore, service supplying plays a key role in CC. Then, it is good opportunity for customers to find suitable and lowly cost service for their project. Specially, Customer must be able to select appropriate cloud service according to their needs and money. It is time-consuming task for consumers to collect the necessary information and analyze from all cloud service providers to make right decision. As well as it is also a highly demanding task from a computational perspective because multiple consumers who have similar requirements conduct same computations repeatedly. They provide all products you might need for moving your business to the cloud. But these product offerings differ in pricing as well as the naming of their services. Some Businessmen already may use on-premise infrastructure or think which infrastructure will use for my project. They may have more complex problems like how to choose a cloud service, which services want use and specially how many costs want to pay for monthly or yearly. Sometimes, someone already use a cloud services, they have lot of problems like more expensive, less flexibility, hard to use, overwhelming options of services, poor management of GUI and tool, complex price schema and other issues. However, they must spend more price and time as useless. Because they could not select best cloud service provider early to their business.

For solving the cloud service selection problem, many researchers have proposed some approaches including multicriteria decision analysis (MCDA) and Brokerage-Based Approach. But we cannot see any machine learning prediction system for solving this issue. This system enables the user to choose from among a number of available choices. In this paper, we make a neural network with TensorFlow to service selection in CC. This system focuses on three main players in CC. There are Amazon Web Services, Microsoft Azure and Google Cloud Platform in the race for cloud services providers. I identify and synthesize several products relevant for web services in Cloud providers. There are Featured, Compute, Storage, Database, Networking, Operation, Identity & Access and Cost. As well as I focus on Small and medium-sized businesses (SMBs). Because these are most aggressive segment in cloud service. It is less-complex IT needs, fewer legacy applications and less IT support than larger enterprises. According to McKinsey's research [1], he confirms about usage of subscription or on-demand technology services as SMBs (few 250 employees) > (larger companies) * 2. As well as He categorized company sizes as very small (5-19 employee), small (20-99) and medium (100-250) like these.

We use Support Vector Machine (SVM), Multiple linear regression (MLR) and Multiple-criteria decision analysis (MCDA). We develop efficient and flexible recommendation system for ranking cloud service providers. I prove accuracy and effectiveness of our approach through an experimental study with the real and synthetic Cloud data.

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CHAPTER 1 – INTRODUCTION

1.1 Introduction to Research

CC come into our focus only you want to increase capacity, add capabilities without investing infrastructure, training new personnel, or licensing new software for your projects. In cloud computing, it covers subscription-based or pay-per-use services in real time over the internet and help to extends existing capabilities [9]. Cloud computing has many characteristics under own conceptional, technical, user experience and economic [10]. There is fault tolerant, service oriented, loose coupling, business model, virtualization, high security, business model and ease use. These characteristics are important to get the essential of cloud computing. Because it helps to determine the scope of research projects and suitable applications running as cloud services. Firstly, we see about services oriented under conceptual characteristics. It has two keys which are abstraction and accessibility. Thus, it doesn't expose to cloud user underlying architecture through virtualization and other technologies. So, it is opacity to user. So, customer don't need to more details of cloud architecture and the threshold of application development. Cloud user can use all features by exploring system parameters such as processing performance and storage capacity. The services of CC are broadly divided into three categories. There are Infrastructure-as-a Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS) [11]. Infrastructure-as-a Service (IaaS) is delivering huge computing resources for processing, storage and network. Platform-as-a-Service generally act as the middle bridge between hardware and application. It abstract infrastructures and supports a set of application program interface to cloud applications. Software-as-a-Service aims at replacing the applications running on PC. You don't need to install and run software on your computer. If you use this method (pay-per-use pattern) without buying the software, then you can reduce your total cost. Most of gaming players use the capability of cloud computing. These services are hardly maintaining and waste many electrical resources. Second is Technical characteristic that has two part as loose coupling and strong fault tolerant [10]. The infrastructures are separated in logic or physic. The platform is isolate abstract layer, that is not affect application running on it. Because it run as client-server model. Thus, cloud user loosely couple with other cloud user, and no data or control dependence. User can only formalization. Cloud provider supply many benefits than on-premise. There are supply backups or redundancy of provider (use load balancing). Because, some reason can happen like request time-out, network congestion, browser collapse, hacker attack, and etc. Economical characteristic is third character. Many business models get more attention about pay-per-use (pay on their usage of these utility service) in CC. CC users can categories for two parts as end user and middle user. End user use cloud services for self-use. But, middle user use cloud services, as well as they provide their professional services to others as cost-effectively. End user sometimes doesn't pay for cloud service provider directly like online game players pay for game but only how long stay online (they don't care about maintain, running of clod system). But medium user pays for cloud service directly. They save money as using CC, because they don't want to manage complex hardware and software, learn how to use tools and gain experience with cloud

computing technology. Other fourth characteristic is user experience. It is depending on human computer interaction. It is important to evaluate CC services is successful or not. The valuable services should be easily accessed and used by cloud user. CC has three reason why user using CC to get more user experience. There are offering easy Internet-based interface, user interfaces are independent of content and web 2.0 increase the interaction between web users and provider. The user experience depends on useful, usable, valuable, findable, desirable and accessible of service provider [12]. Other characteristics are TCP/IP based, virtualization and high security. TCP/IP provide reliable connection, a connection-oriented service between remote applications. Data center uses virtualization technologies in different levels. High security of CC provides by using loos coupling, abstractions, virtualization, privation of cloud. Then, it avoids exposing the details of corresponding implementations. These characteristics are more importance when using CC. We can compare these characteristics according to give these functionalities to cloud user.

1.2 Background of the Study

CC is TCP/IP based on integrations and high development of IT such as huge memory, high performance network, reliable, and fast vCPUs system architecture. After the IBM and Google announced collaboration in CC, then CC become popular beside the web email, EC2, Google App Engine, Saleforce's CRM [13]. CC services are divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS) [11]. This model has five deployment models: private cloud, community cloud, public cloud, and hybrid cloud. Private cloud is used by a single organization comprising multiple the organizations. Community cloud is used by community of consumers from organizations that have shared concerns. The cloud infrastructure is used for open use by the general public. Hybrid means that is a composition of two or more distinct cloud infrastructures. Some researchers have analyzed pricing data across all available AWS regions for 60 days for a variety of Spot Instances. They find that Spot instance pricing will differ from region to region as pattern [14]. They analyses impacts that a coarse-grained AWS region plays in affecting spot prices. As well as they analysis what is pricing volatility and whether user can be confident about average pricing point are reliable or not. According to [14] research, we can get clear idea about aws ec2 pricing that change region by region. When we can see about powerful instance, cheaper and more reliable pricing one would be get in Canada than another region. For less powerful instance, the cheaper and more reliable one is in the EU and US regions. Aws spot instance widely use through aws customers, that spot instance utilize capacity with unfixed (change by time) and provide predicting pricing [15]. They use long short-term memory (LSTM) algorithm to predict time series of the prices. They apply cross validation technique to extract some features and help to make predictions for 10 regions, and measure the performance using root-mean-squire error (RMSE). In machine learning model, Cross validation [16] is used widely for evaluate training data with more benefits. There are using data to train model and fit the model well. We want to clean up new datasets coming from different distributions. The model may end up with problem of bias/variance (bias can come up when function underfit the data). That means when we get 10% in train dataset, get 11% errors with test dataset, then we end up with this higher variant problem. They use k-fold cross validation [17] to avoid this problem.

They said based on their result, they try to find the availability zone that less become over on-demand price and less changing price over time. So, customers allow this to choose the most stable available zone.

1.3 Short description of the problem and solution

Problem:

CC is a tremendous and attractive platform that offer resources as services. Many cloud service providers coming to the world to supply these services because of economic advantages and demand. When many cloud services are available, they may provide same functionalities to cloud users. Then, cloud users may come up with a lot of problems when selecting services for their projects. Because, without the usage of service, selecting a best provider is very difficult. Unlike web services, CC services provide a scalable and customizable solution to access applications and resources. As well as they provide a large pool of virtualized resources to give elastic services that meet the needs of its users.

Thus, a recommendation system is needed to evaluate provider based on some specific factors and feedbacks. Those factors will differ for customers to customers.

Solution:

Bearing these challenges in mind, I apply more methodologies to get final recommendation. In this research, I focus only on AWS, Azure, and GCP cloud services providers because other service providers cannot give tremendous competition when supplying their services. According to [19] research, they review the top leading cloud providers (AWS, Azure, GCP and Oracle), surveys their offering related to High Performance Computing (HPC). Each one of them has their own unique value that enable it to survive in the market and make it a real competitor.

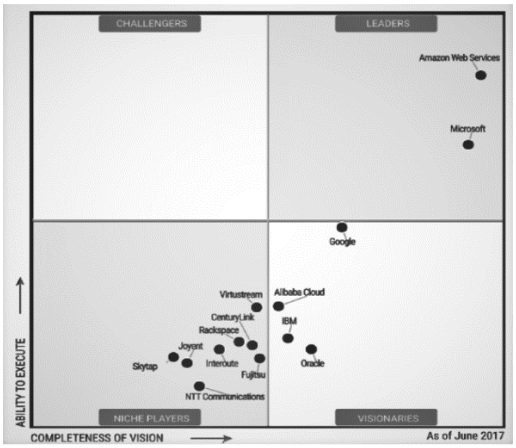


Figure 1: Gartner's Magic Quadrant for Cloud Infrastructure as a Service, Worldwide June 2017

Huge amount of data is always being generated by everything around us and it produces by every digital process, sensors, social media exchange systems, mobile devices, etc. We can use big data analytics to examines large amount data for uncovering hidden patterns, correlations,

and other insights. If you extract meaningful value from big data, we want to optimal processing power, analytics capabilities, and skills. If we use machine learning, a number of algorithms are explored in order to predict the results. As well as we can learn without being explicitly programmed (rules-based programming) [7]. It has three types that we can select to predict result. There are supervised learning, Unsupervised Learning and Reinforcement Learning. According to this research, I used the Supervise learning. So, we should have past data sets to learn and make future predictions. I could find dataset of AWS EC2 for prediction algorithm [8].

According to project type, firstly we want to identify which type of project that user hope to predict after asking user. User just want to select which type of project that want. After identify type of project generally, we want to identify as advanced. For that, I want to more details like project type, performance, size of project (E.g.: small database, high performance large business critical application, low latency interactive application), memory size, vCPUs and other factors. After, we identify about customer project, we can find which Instance type is suitable for their project. We can use this for other Machine family type like these. We use Multiclass Classification with Support Vector Machines (SVM) to recognize to instance type for customer project. After, we identify instance type of virtual machine, we can predict price for that machine. Then, I hope to use (Multiple-criteria decision analysis) MCDA method [3], because lack of dataset about user feedbacks. MCDA is the good method to solve these types of problems. Other thing is that it is directly depend on user preference(weight) for these criteria.

Now, we have many factors after calculating Instance family (recommendation for project type), prices (predict cost according to the recommendation and other user requirement). So, Sometimes, Customer not only want low cost, but they may also have different external requirements. There are Familiarity (Windows user may like to Azure), Quality of Service, Security (AWS and Azure has more security features), Discount Rating (more discount rating available in GCP), Other Services (more services available in AWS), Availability (Some company can have Subscriptions that already purchased) like more non-functional requirements. We cannot drop these requirements, So, I hope to use MCDA method [3] to decide final selection (who is the best provider) from these cloud service providers.

CHAPTER 2– LITERATURE REVIEW

2. 1 A novel brokerage-based architecture

- They design a unique indexing technique for managing the information of a large number of Cloud service providers. They develop an efficient service selection algorithm that rank potential service providers and aggregate them if necessary. They have proved it using an experiment study with real and synthesis cloud data.
- A Cloud broker is an intermediary between users and service providers. It helps the users choose services tailored to their needs.
- The Cloud broker, which has a contract with the Cloud service providers, collects their properties (e.g., service type, unit cost, and available resources), and the consumer's service requirements.
- This architecture includes two key technical **issues**.
    - Construction of the index for managing the service providers.
    - Query algorithm for the service selection.
- A. Indexing Cloud Service Providers
    - CSP-index is developed using the B+-tree (it is important to design an efficient index structure to facilitate information management and retrieval.)
    - B+ -tree is widely adopted in commercial database systems and provides the great foundation for our new index structure to be easily integrated to existing systems.
    - The internal nodes of the CSP-index have the similar format as the B+ -tree and serves as the search directory.
    - They use bellow measures as data structure.
        - Service Type, Security, Quality of service, Measurement units, Pricing Units, Instance sizes, Operating system, Pricing, Pricing sensitivity, Subcontractors.
    - Index Construction:
        - **Property Encoding -** This encoding differs according to the types of the properties. E.g.: [(10G, ∞), (1G,10G), (500M,1G), (0,500M)]. If the storage capacity of a service is 800M to 2G => encoding '0110'.
        - **Relationship Encoding –** It represents the relationship using a binary bit array with three bits. E.g.: 1 bit for subcontractors are present, 2 bits for subcontractor provides computational or storage services, 3 bit for subcontractor provides security, privacy, or search related services.
        - **Index Key Generation –** It generates the integrated encoding by concatenating the bits representing the service type with the XOR-ed results of the remaining property encodings.
            - **E.g.:** We suppose, SP1 service provider provides bellow,

1. service type ‘0001’, 800M to 2G storage space to each end user at 10 cents/min with medium service quality and medium privacy protection.
2. ‘0110’(storage), ‘010’(cost), ‘010’ (service quality), ‘010’(privacy)
3. **Integrated Encoding (Esp1)** = 0001|| (0110 ⊕ 010 ⊕ 010 ⊕ 010) = 00010100

- **k-means algorithm** - k is number of service types. Hamming distance (denoted as Dh) is between the encoding of each service provider and its closest cluster center. S means a scaling value is used to partition the dimensional space into regions, where each region holds a cluster of points. It depends upon the number of regions we aim to generate. Espi is the property encoding of service provider i. Eck is the encoding of the cluster center ck which is closest to the service provider i.
  - **Keyspi - S · k + Dh (Espi, Eck)**
- **Query Definition –**
  - A user sends a service selection query to the broker which specifies what properties and values he/she expects from the service providers.
  - Q = (QP1 : D1),(QP2 : D2),...,(QPk : Dk)
  - QPi ($1 \leq i \leq k$) => property that the user requests the service provider to possess
  - Di is the user expected values of property (requested value)
  - The result of the query will be the service provider that satisfies the most property requirements.
  - E.g.: Q = (Service Type: 0001), (Cost: [50cents/min, 80cents/min]))
- **Generation of Testing Datasets -** They identified and extracted a set of common properties based on common business recommendations for service selection.
  - **E.g.: Service Type:**
    - 1- service on-demand
    - 2 - reserved instances
    - 3 - specialized services such as custom Ips
  - This gave us our starting set of ten data points and shaped the representation of service providers.
  - With the starting data points, we generated 10,000 data points representing synthetic providers.
  - They use a pseudo random number generator to generate a subset of the total possible 1010 combinations and filter out the outliers.

2.2 Multicriteria Decision Analysis

- MCDA is modeled after the way humans are thought to make decisions. MCDA assists in decision making mainly by choosing, ranking, or sorting the actions.
- MCDA is not only a collection of theories, methodologies, and techniques but also a specific perspective for dealing with decision-making problems.[3]
- It demonstrates the integration of MCDA techniques and cloud computing based on their usage and popularity. Hence, they reviewed the current literature and identified the different types of problems.
- **Goal:**
    - MCDM is a collection of methodologies for comparing, ranking, and selecting multiple alternatives, each having multiple attributes. It depends on a matrix called the evaluation matrix, decision matrix, payoff matrix, or evaluation table.
    - MCSP selects the best alternative from a finite set of alternatives, all of which are known a priori.
    - MCMP selects the best alternative from a very large or infinite set of alternatives, not all of which are known a priori.
    - MAUT finds a utility function reflecting the usefulness of a particular alternative.
- **MCDA methods can be categorized into two types:**
    - **multi attribute utility theory (MAUT)** - find a function reflecting the utility or usefulness of a particular alternative.
    - **outranking methods** - It is better in scenarios with a small number of alternatives (hope to compare types) but a large number of criteria.
- AHP (Analytic Hierarchy Process) is based on a pairwise comparison. a popular and widely used method for MCDA. After making the comparisons, the best alternative with respect to each attribute is usually selected.
- They present several applications of these MCDA methods in the selection of cloud services. They compare several methods by synthesizing and reviewing the present literature. Several real-world examples with current applications of different methods are provided.

2.3 Multi-Class Support Vector Machine

Huge amount of data is being generated by everything around us at all times and it produces by every digital process, sensors, social media exchange systems, mobile devices, etc. We can use big data analytics to examines large amount data for uncovering hidden patterns, correlations and other insights. If you extract meaningful value from big data, we want to optimal processing power, analytics capabilities and skills. If we use machine learning, a number of algorithms are explored in order to predict the results. As well as we can learn without being explicitly programmed (rules-based programming) [7]. It has three types that we can select to predict result. There are supervised learning, Unsupervised Learning and Reinforcement Learning. According to this research, I used the Supervise learning. So, we should have past data sets with labels to learn and make future predictions. As well as, it has two parts. There are regression and classification type. Under the classification type, we can see Multi-Class Support Vector Machine as a very efficient learning methodology in Artificial Intelligence. The standard Support Vector Machines are designed for dichotomic classification problem (two classes only. called also binary classification). But The multi-class classification problem is solved by a decomposition to several binary problems (standard SVM can be used) [20]. Using multi-class SVM, we can solve multi-class problems directly [21,22].

In [22], they present efficient algorithm for classification of characters using Multiclass Hierarchical SVM, and a variant of Multiclass SVM for recognition of printed Tamil language characters. They proved that their algorithm is more efficient than some of the commonly used classifiers (Multilayer perceptron, KNN, Naive Bayes, decision tree and other rule-based classifiers). The accuracy of the algorithm depended on two parameters settings. There are RBF (Radial basis function) Kernel parameter σ and regularization parameter C.

Classifier	Accuracy (%) with		
	3 characters	7 characters	20 characters
Multiclass Hierarchical SVM	96.85	96.23	96.86
Multilayer Perceptron	91.8	95.45	93.43
KNN	89.40	90.05	89.90
Naïve Bayes	84.5	88.90	88.20
Decision Trees	91.0	92.84	93.23

Table 1: Comparison of classifier performances

Face recognition system is a machine learning system that is used for the identification and verification of a face from a video or digital image. If we want to recognize more than two faces of persons, then multi-class support vector machine is very useful to classify the face image and assign a class label based on the learning of the classifier. A binary classifier can be used to recognize only two faces for satisfactory recognition of faces. In case of recognizing more than two faces a multi-class classifier is used [23].

For the identification of newborn babies, we can use Biometric recognition system, [25] research explores the possibility of using face recognition for determining the identity of newborns. Firstly, input face image is first divided into nine overlapping regions. After extract face features such as mouth, chin, and forehead, they concatenated into a single feature vector. Then, they perform one shot similarity using multi-class SVM. One shot similarity measure from a set of positive samples and a set of negative samples are available. Feature vectors are trained and classify through multi SVM.

2.4 Multiple linear regression

This is under regression type of supervised learning model. Each model is trained using data of used car market collected from German e-commerce website. In this paper [24], they conducted a comparative study using multiple linear regression, random forest regression and gradient boosted regression trees to build a price model of used car. These each algorithm used data scrapped from e-commerce website. They finally find best predictive model for predicting used car price. Final test data have 304,133 rows and 11 attributes. The results are then compared by using mean absolute error as a criterion.

MAE is a negative oriented score which means that the closer the value is to zero, the better the model prediction.

$$MAE = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i|$$

According to result, gradient boosted regression trees gave highest performance with MAE =0.28. Next, random forest regression gave MAE=0.35 errors and multiple linear regression with 0.55 errors. They recommended gradient boosted regression trees to develop the price evaluation model.

According to [28], they forecast house price from historical data of property markets. They target to find useful models from machine learning for house buyers and sellers. They demonstrate three regression models (Linear Regression, Random Forest Regressor and XGBoost Regressor) to identify best performance method. Finally, Linear Regression displayed the best performance for this Dataset and can be used for deploying purposes.

2.5 Ranked Voting Method

They use a dynamic and flexible framework using Ranked Voting Method [27] is proposed which takes requirement of user as an input and provides a best provider as output. Because User may provide its QoS expectation as well as service providers may also express the offers. In this paper, they try to identify QoS metrics and defines it in such how that user and cloud provider each will specific their expectation and offers severally into quantified form. Cloud user want to identify its QoS measures that introduced by CSMIC organization. CSMIC have developed a SMI [26] framework that is a standard measurement flexible framework (user can add or remove QoS metrics easily). SMI has seven major characteristics which helps decision makers to measure QoS requirement of customers.

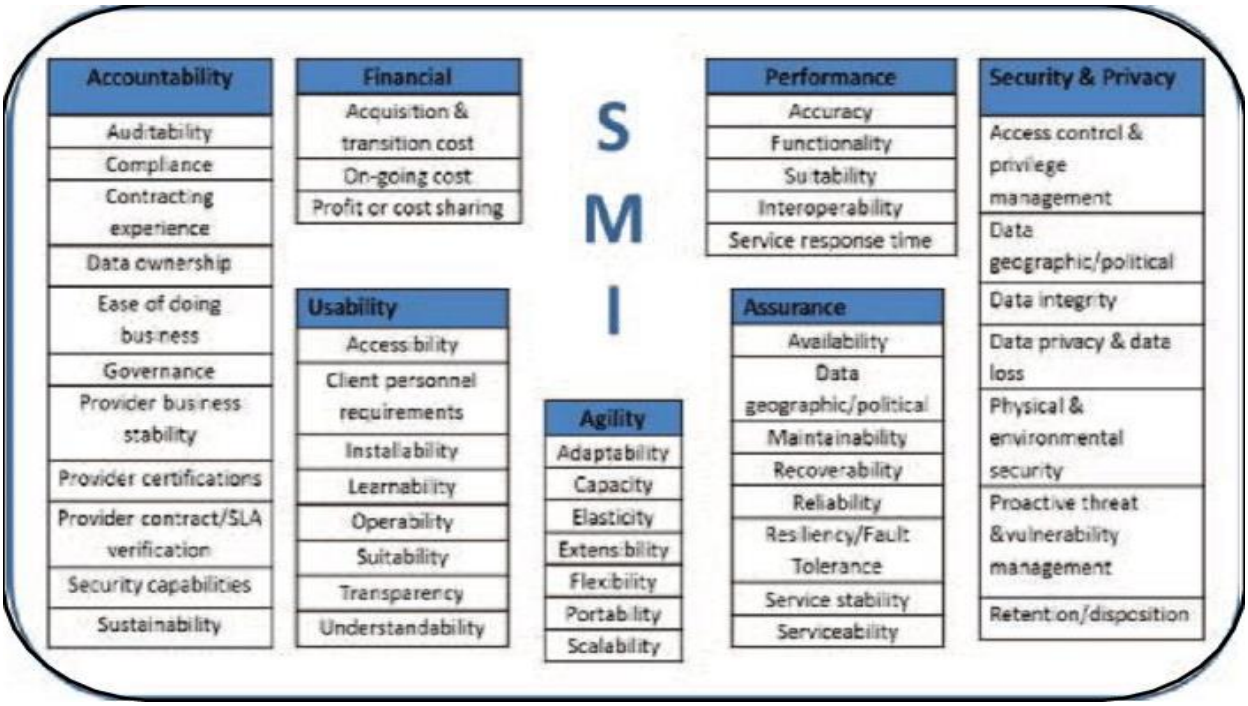


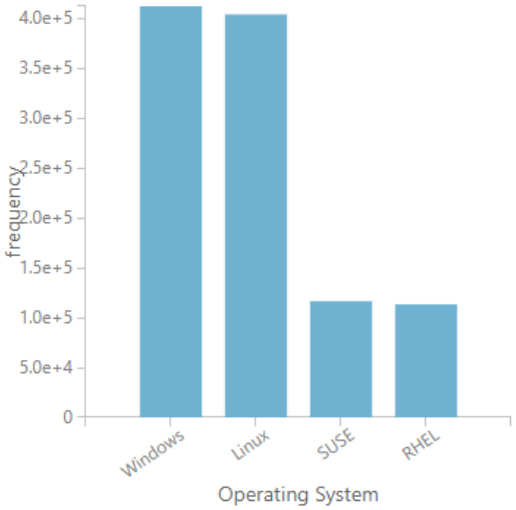
Figure 2: SMI

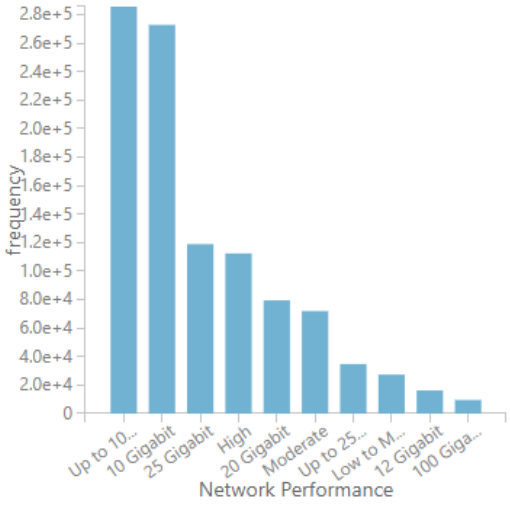
According to these attributes, various cloud providers can specify their QoS offers and various customers can specify their QoS requirements at different quality levels. Then, with help of this method, customer can understand each services provider clearly and it also helps to service providers for advertising their service in a better way. Customer can provide their own vote list as per its requirements. For comparing QoS values (even though they may be of different value types), they decide a set of rules. This method should not use inefficient provider's informati

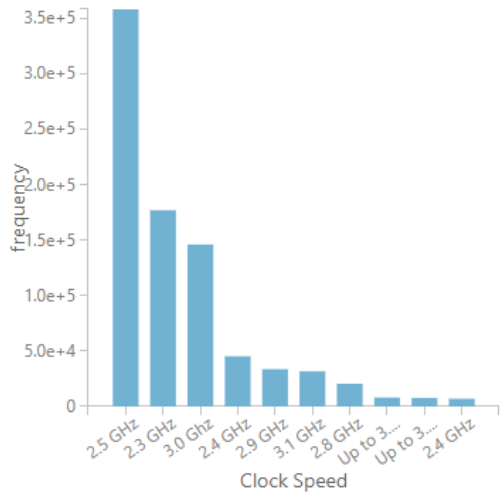
2.6 Main Services types that can be critical when selecting

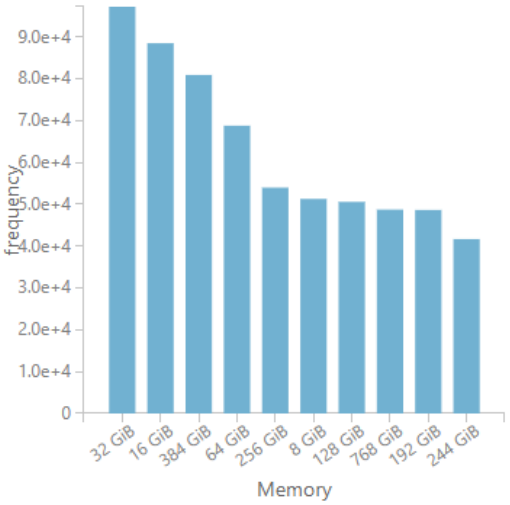
Service Type	AWS	Azure	GCP	Description
1. Virtual servers	Elastic Compute Cloud (EC2) Instances	Virtual Machines	Compute Engine	Virtual servers allow users to deploy, manage, and maintain OS and server software.
2. Cloud virtual networking	Virtual Private Cloud (VPC)	Virtual Network	VPC Network	Provides an isolated, private environment in the cloud.
3. Object storage	Simple Storage Services (S3)	Blob storage	Storage	Object storage service, for use cases including cloud applications, content distribution, backup, archiving, disaster recovery, and big data analytics.
4. Virtual server disks	Elastic Block Store (EBS)	managed disks	Persistent Disk	SSD storage optimized for I/O intensive read/write operations.
5. Relational database	RDS	Database for MySQL	Cloud SQL	Managed relational database service where resiliency, scale, and maintenance are primarily handled by the platform.
6. NoSQL / Document	DynamoDB	Cosmos DB	Datastore	A globally distributed, multi-model database that natively supports multiple data models: key-value, documents, graphs, and columnar.
7. Caching	ElastiCache	Cache for Redis	Redis	An in-memory–based, distributed caching service that provides a high-performance store.
8. Monitoring	CloudWatch	Application Insights	Google Stackdriver Monitoring	Application Insights, is an extensible Application Performance Management (APM) service for developers and DevOps professionals.
9. Firewall	Web Application Firewall	Firewall	Firewall	Provides inbound protection for non-HTTP/S protocols, outbound network-level protection for all ports and protocols, and application-level protection for outbound HTTP/S.

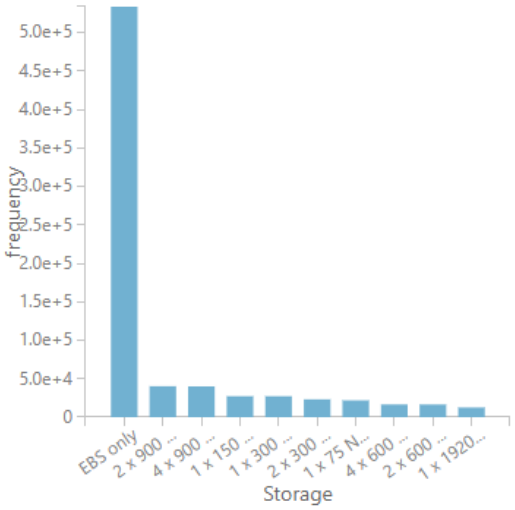
2.7 Virtual Machine Usage – AWS EC2







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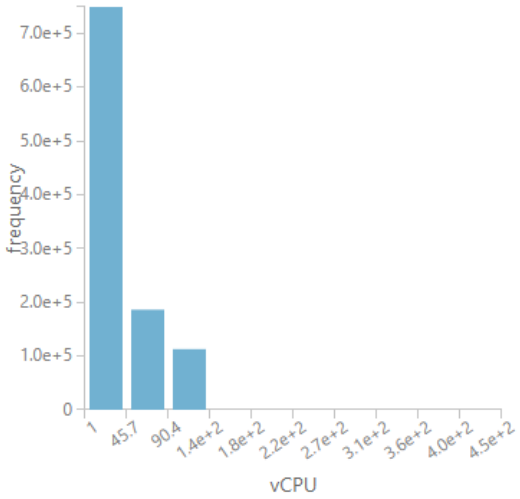
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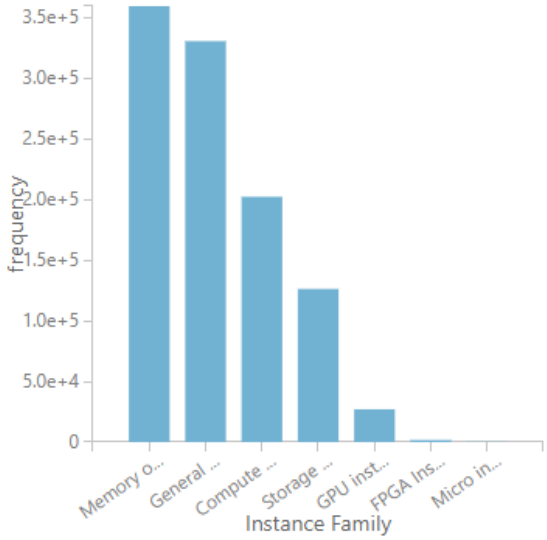
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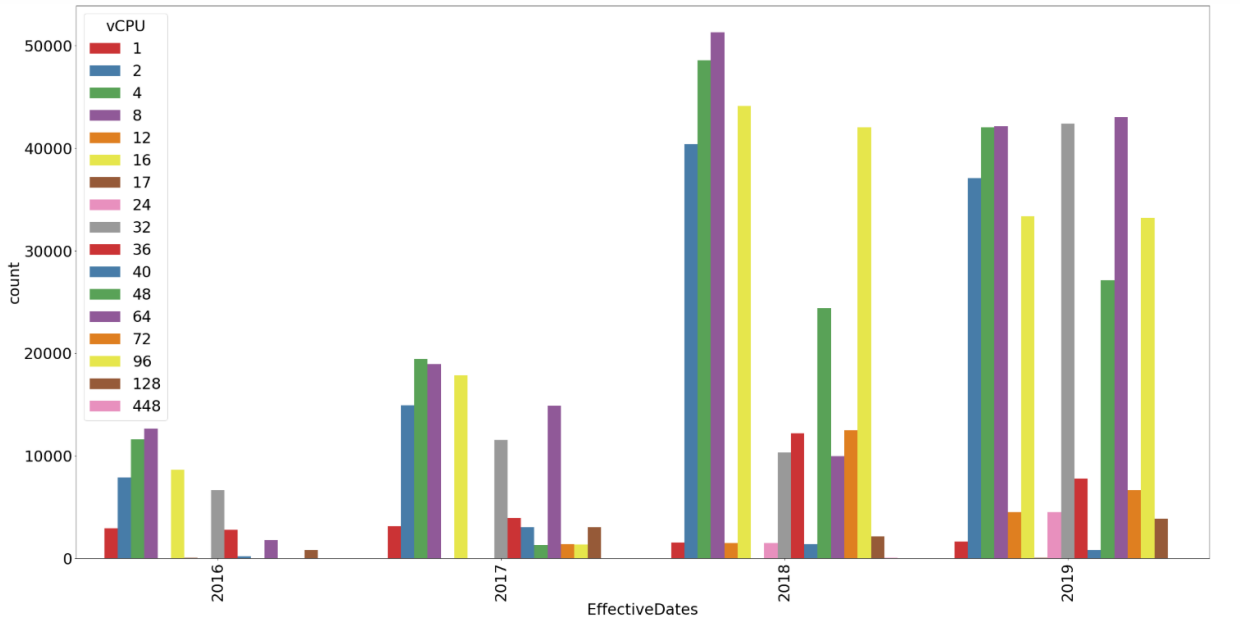
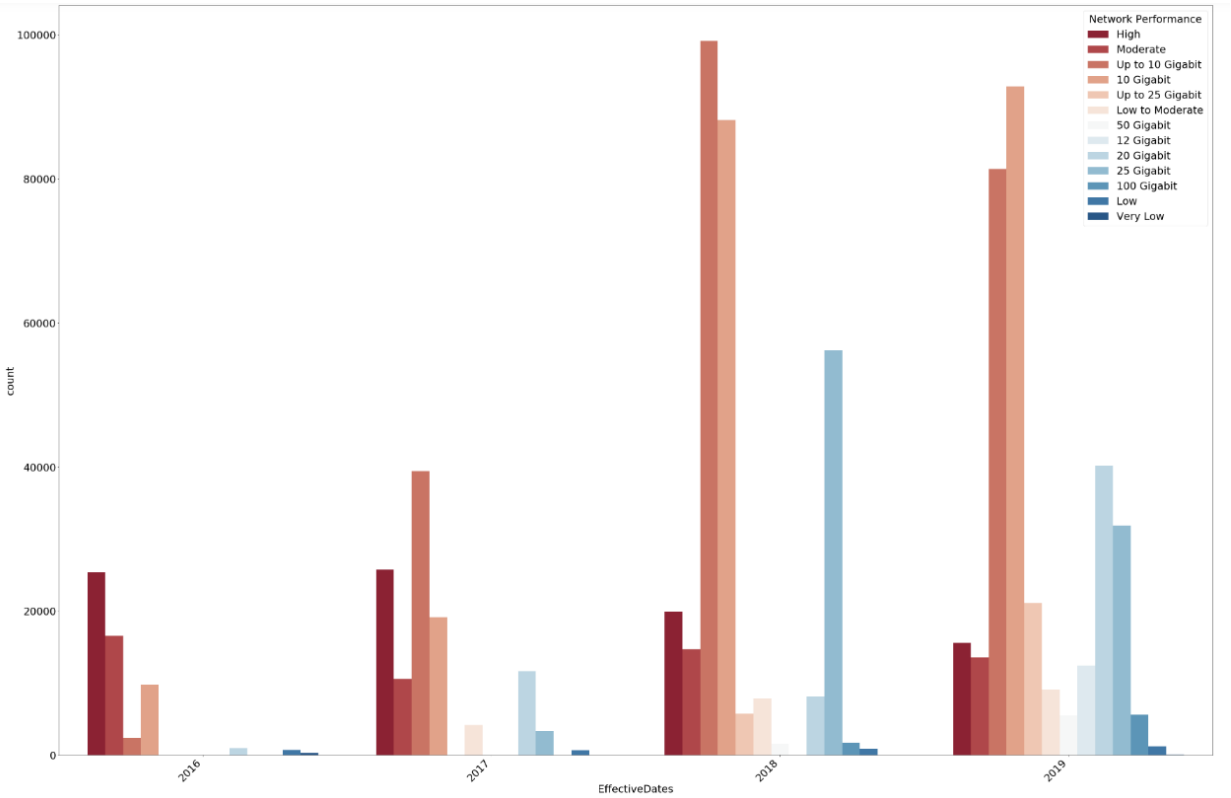
Storage ...
GPU inst...
FPGA Ins...
Micro in...
Instance Family

2.8 AWS EC2 Customer Usage with Year

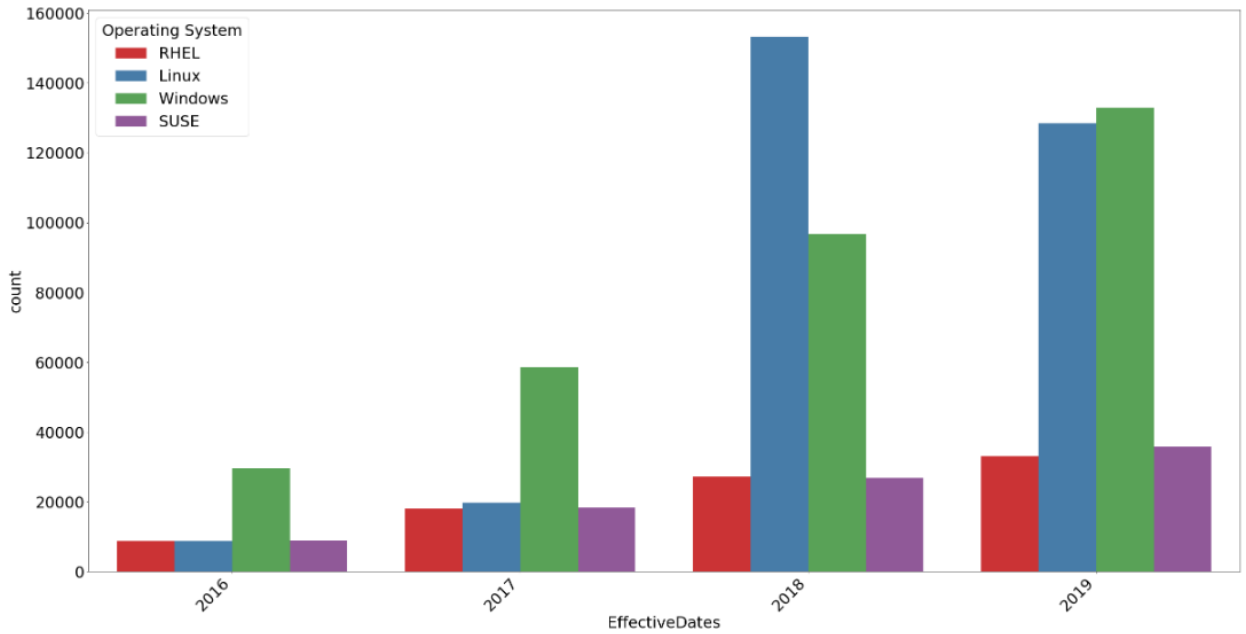
2.8.1 vCPU with Year



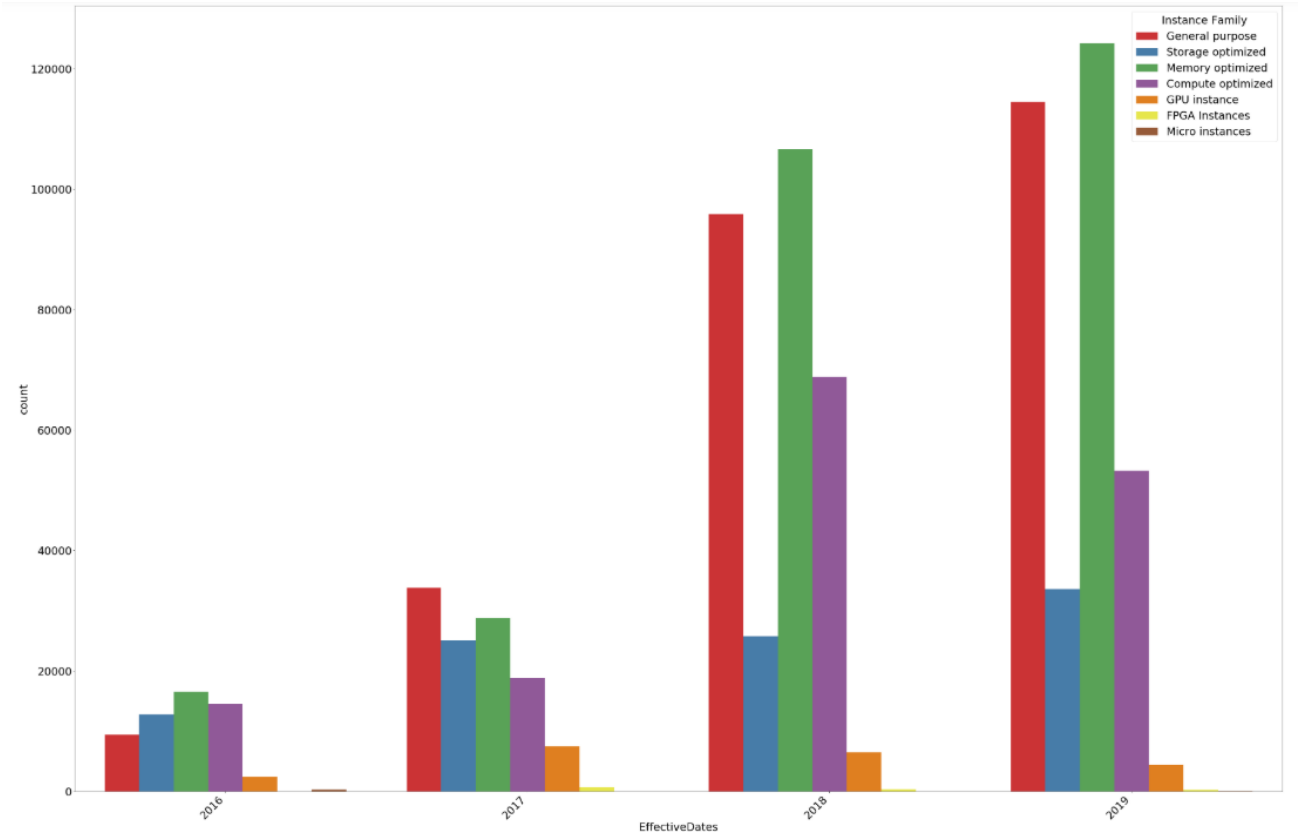
2.8.2 Network Performance with Year



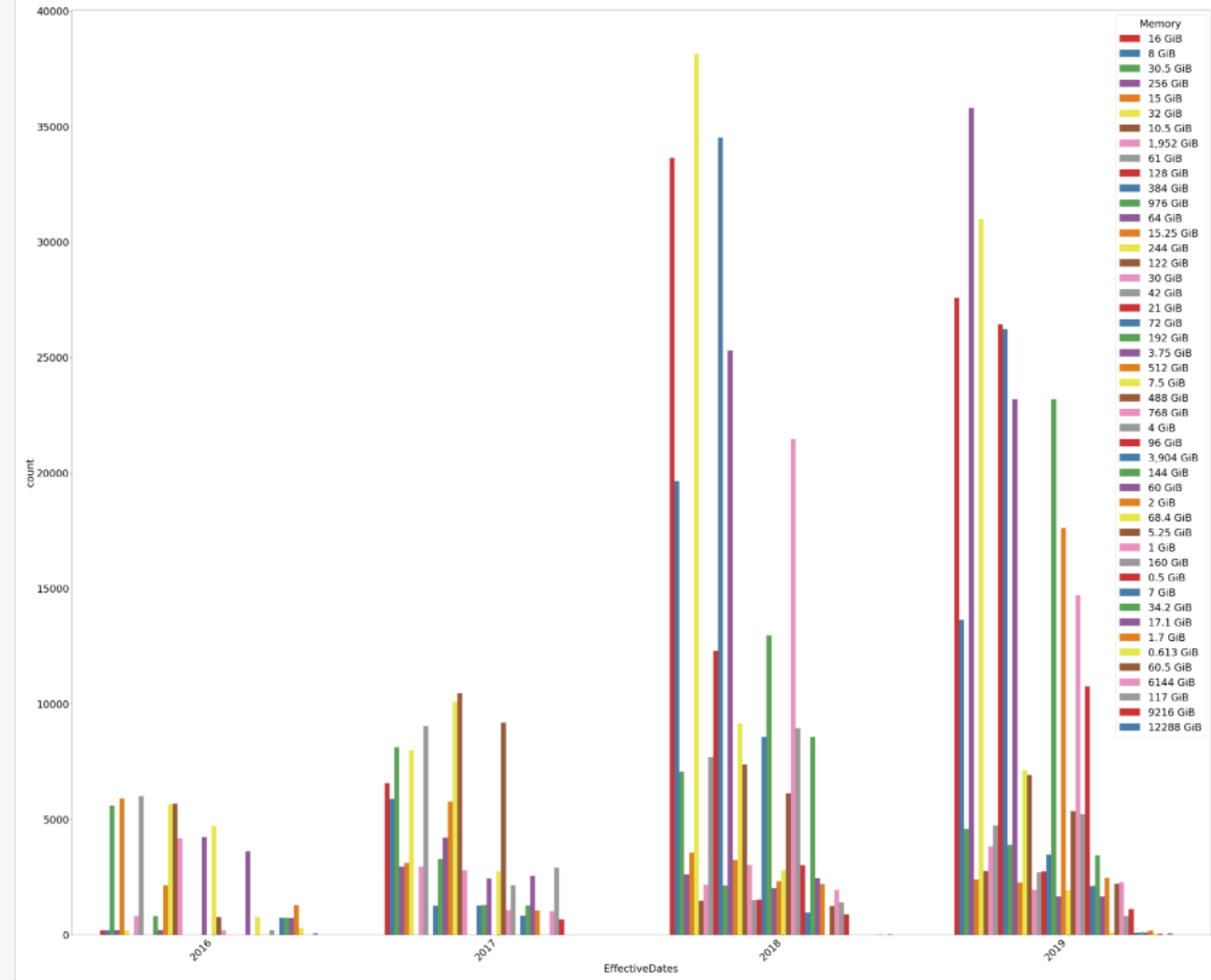
2.8.3 *Operating System with Year*



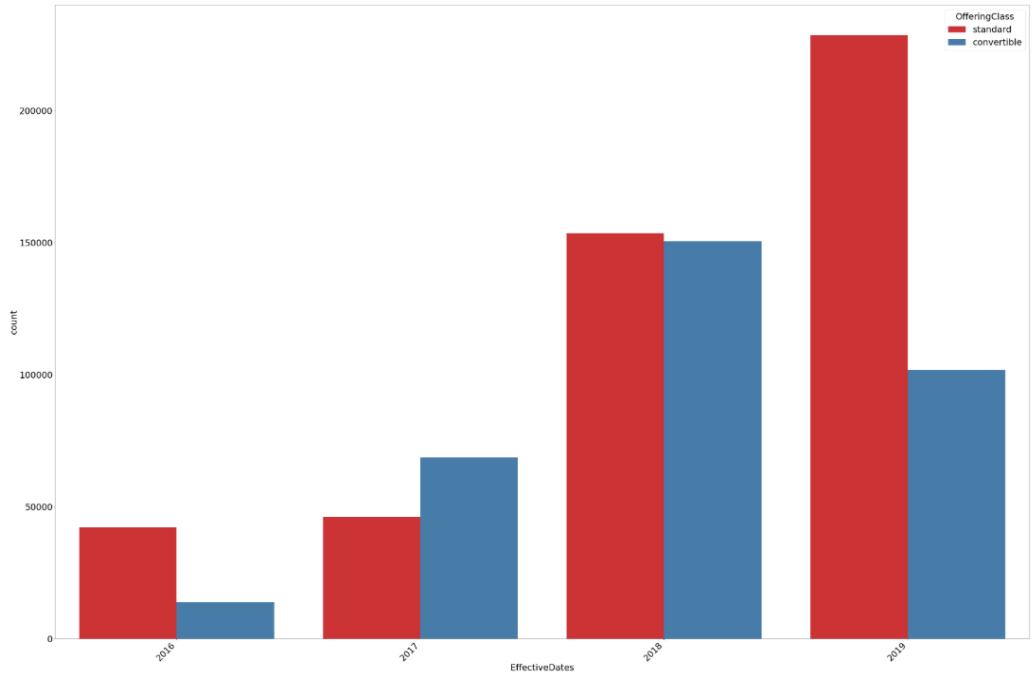
2.8.4 *Instance Family with Year*



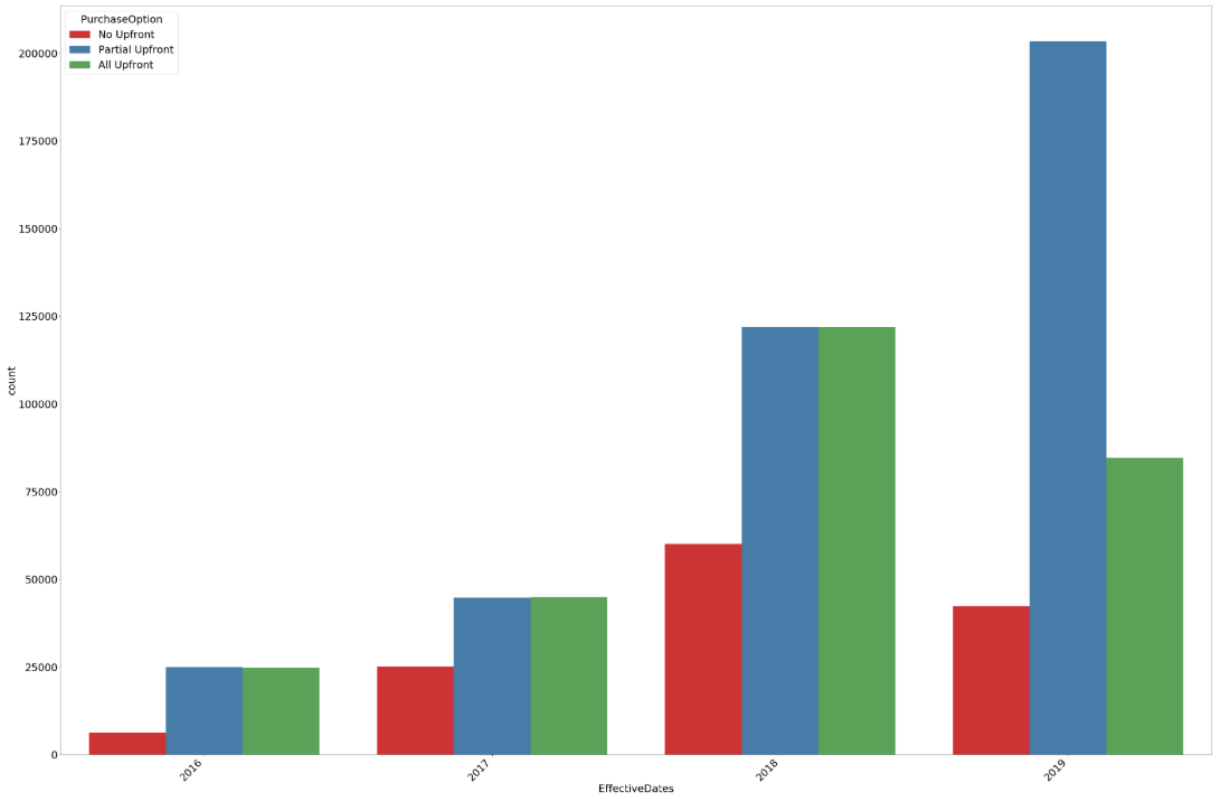
2.8.5 Memory with Year



2.8.6 *Offering Class with Year*



2.8.7 *Purchase Option with Year*



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