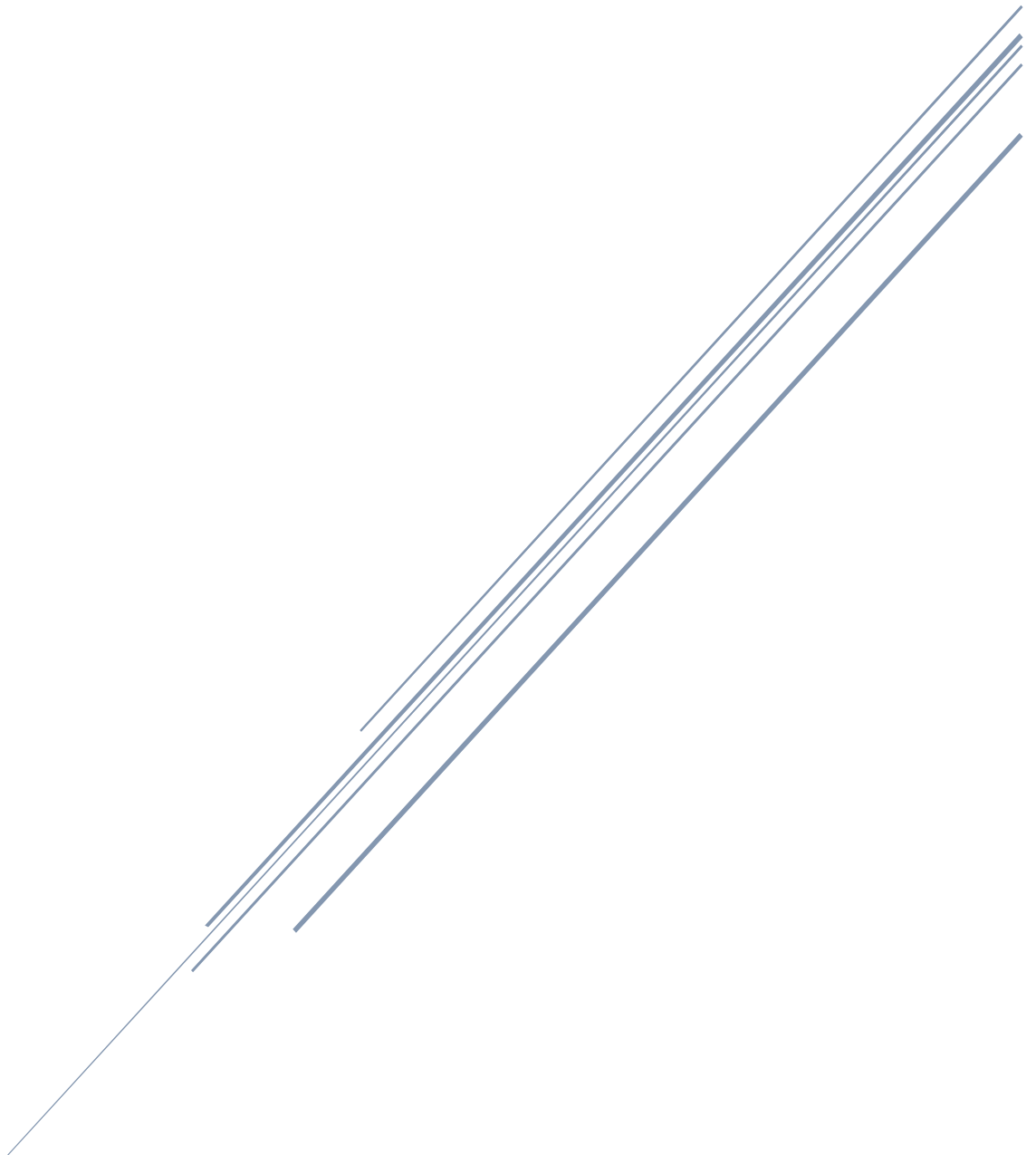


NETWORK PROGRAMABILITY

ASSIGNMENT 1



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Table of Contents

Introduction	2
The impact on the industry	2
Network Professionals in Cloud Computing	4
RESTful Web Services in Cloud Computing	5
Software-Defined Networking in the Industry	6
Conclusion.....	7
References	8

Introduction

Over the last few decades, the rate that computing has evolved has been insane both in how much it has evolved and how fast it has evolved. We very quickly went from only massive companies having access to computers and the internet to about 20 years later everyone having a computer and internet in the home. This would become quite an important part of our lives as these days I don't think a day goes by when most people don't rely on some technology of some kind, I don't think I'd be able to live without my phone these days.

In more recent years though, the introduction of cloud computing has taken the technology world by storm. It has completely changed the way we store, process and access our data and in some respects the way we purchase and use software. Cloud computing at its very basics while still a very evolving concept, it's a convenient way for users to access and share resources these can be networks, servers, storage, applications, data or services which can be easily deployed with little effort from the user or the organization [1]. Cloud computing does many different models and scenarios where it can be deployed, which is what we'll cover throughout the course of this paper.

The impact on the industry

The shift towards cloud computing has made quite a substantial change within the industry. It's come along and replaced a few things but has also introduced new things that have completely revolutionized the way that end users and organizations work. Cloud computing can be split into multiple 'layers' which serve different purposes, these are 'applications', 'platform', 'infrastructure' and while not as big as the other three 'datacenter'. This is displayed in the diagram below.

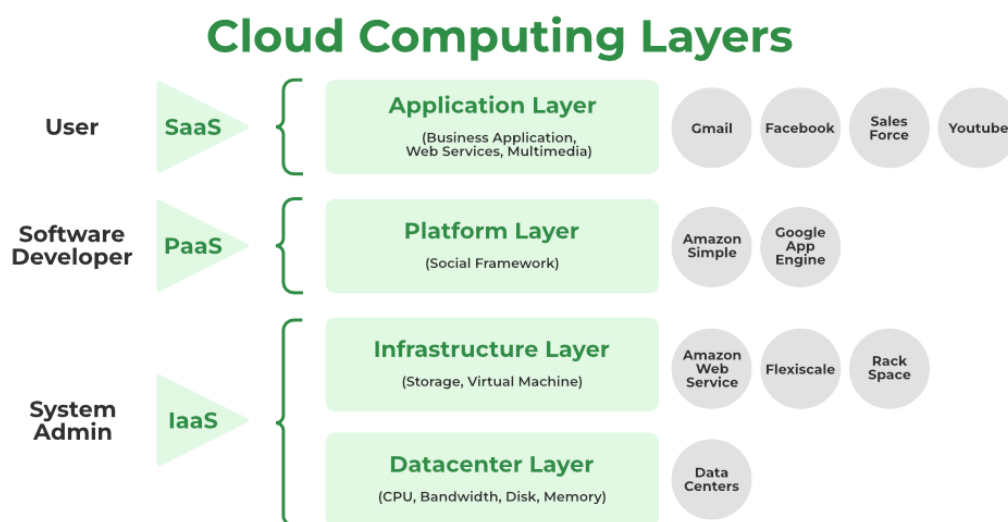


Figure 1 Cloud Computing Layers [2]

Within the application layer we have SaaS (Software as a Service) which is used to allow customers to use a software using the internet without having to install the software on their own computer [3], examples of software as a service would be Microsoft 365 (used to be Office 365), Slack and Zoom. This implementation has shown to be popular within companies and institutions as they're now adapting a more "cloud-first" strategy when it comes to obtaining new software [4] as it's much easier to deploy compared to more traditional software as there is no longer any need to install such software on every machine they have, and it means that users can use it remotely with ease.

The introduction of SaaS has changed how software is sold to consumers quite drastically, before if you wanted software you would have to purchase a license for so called “off-the-shelf” software and then install that software on your own machine but now software vendors are going for more of a “pay-as-you-go” subscription and as said before this would be accessed over the internet [4]. This has proven to be quite a successful model for both consumers and software vendors as it allows consumers to receive consistent updates to the software that they pay for and complete ease of use as sometimes it’s as much as clicking a link and signing in and it ends up making software vendors a lot more money in the long run, which in 2022 pulled in 213 billion USD and is predicted to be upwards of 300 million USD by 2026.

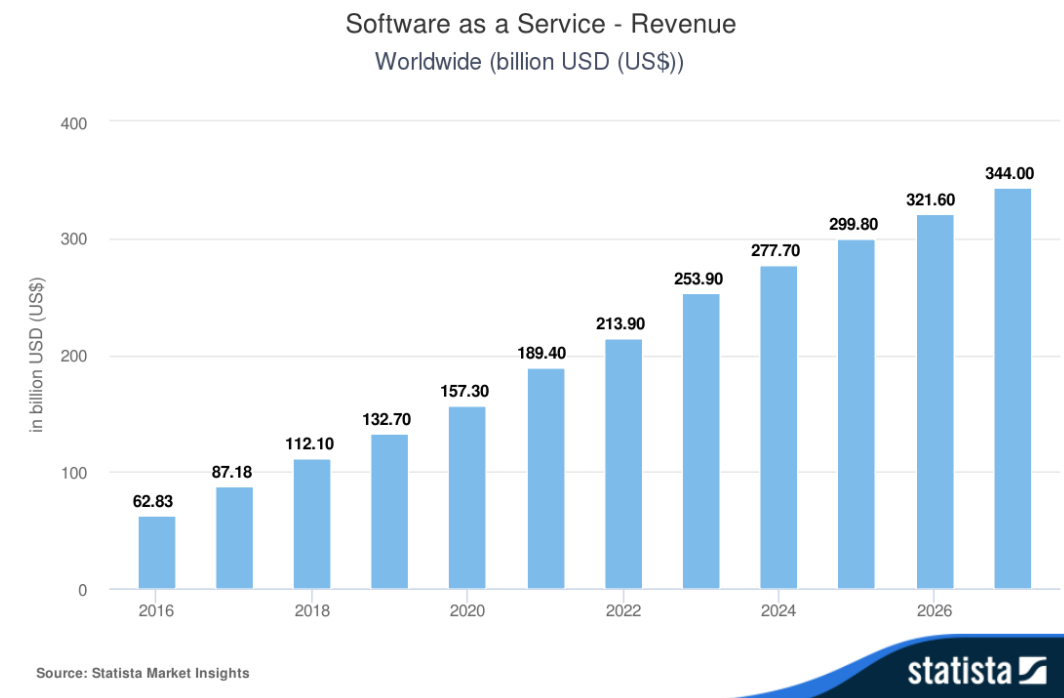


Figure 2 Revenue of Software as a Service chart [5]

The arguably most useful layer within cloud computing is IaaS (Infrastructure as a Service). IaaS helps save customers money by offering them computer infrastructure in a mostly virtualized environment instead of them going out of their way to find the space to install their own servers or networking equipment [6]. The most widely used IaaS service now is Amazon’s side venture Amazon Web Services, it was released in 2006 and is currently the pioneer of IaaS due to its cheap cost and ease of use [7]. IaaS services in the long run if chosen to be used will save organizations and users a lot of money, the use of an IaaS service is typically billed either monthly or based on how much resources are consumed by whatever they are being used for [6].

Using IaaS is a big win for both the consumer and the service provider, but it comes with both advantages and disadvantages. An IaaS service brings the advantage to the consumer of being able to change the resources that they need almost on-demand and without touching any hardware at all and with it being pretty low-cost as is, will save them a lot of money on utility costs as they don’t actually have to have anything physically running at home or in the office for the resources they need to actually run.

The disadvantages of IaaS are that downtime and issues are completely out of their control, if the IaaS provider is suffering from problems such as internet problems, power disruption, system bugs or other physical concerns, the user is left completely in the dark until they are fixed [7]. A few examples of when this has happened include the situation OVH found themselves in around 2 years ago in 2021 when one of their data centers in Strasbourg caught fire and was destroyed, this not only caused entire data loss on every server hosted there, but also took down 3 other datacenters close to that location for around 24 hours [8]. More less severe examples would be when RackSpace was down for 3 hours due to a power cut-off in 2007 and when Microsoft Azure experienced 22 hours of downtime due to an OS system update [7]. Regardless of these though, users and organizations are still choosing to ditch purchasing their own hardware and switch to using cloud infrastructure.

Network Professionals in Cloud Computing

As more and more organizations move all their IT infrastructure to cloud services, network professionals have had to undergo changes to help with this migration and help with maintaining the new system. This may be a big change for some professionals as they've very quickly gone from working hands on with equipment that they can find in their workplace to having to adapt to cloud computing sometimes with very little notice.

An example of changes already being caused by adapting to cloud computing would be the fact that some job roles are getting merged into one or sometimes becoming completely unneeded. Usually in IT, you would have both a systems administrator and a storage administrator. You would have the systems administrator managing the day-to-day server operations such as setting up user accounts and managing the servers and the storage administrator would manage the physical storage [9]. Now that IaaS has become a thing, these roles are both merged into one as virtualization plays a big part in making IaaS what it is which combines both things into one. This is why you see most network professionals these days who are qualified to do multiple things and have experience in multiple areas as cloud computing has made them evolve and learn even faster. They're almost forced to do this as with things becoming much easier to manage through cloud computing, the number of staff needed in IT is going to begin to decrease.

The example given previously isn't the only role that's been merged into one, not saying that the following are what every organization has done, but these roles are examples of some. System and Storage Administrators have become Infrastructure Engineers, Software Developers and Support Engineers have become Development Operations Engineers, Oracle DBA, DB2 DBA and Enterprise Architects and Business Analysts have become Business Architects [9].

With already existing roles evolving though, new roles will also be created. For example, with the role of DBA already evolving into the role of a data engineer, someone will need to step into a role to manage the responsibilities of both database administration and a business intelligence developer, more specialized roles will also be created if not already to be more "cloud-based" as enterprise architects and developers will be needed that specialize in that area [9].

RESTful Web Services in Cloud Computing

RESTful (Representational State Transfer) is a way that can be used to design web services that need to be efficient and scalable. It follows a few principles such as:

- Uniform interface - this means that all API requests should look the same and should make sure that the data all belongs to one URI (uniform resource identifier) [10].
- Client-server decoupling – this means that client and server applications must be completely independent of each other and the only information that should be known by the client is the URI of the resource needed as it shouldn't and cannot interact with the server in any way else [10].
- Statelessness – this means that the application on the server isn't allowed to store any data about a request and a session state on the server isn't required, this also means that each request sent to the server must include all the information needed [10].
- Cacheability – this means that resources should be cacheable on either the client or server side or both, server responses will also need to have information on whether the delivered resource allows caching or not, this will improve performance for the client side but will also increase scalability on the server side [10].

As a result of these main principles, REST is well suited for use within cloud computing. REST will also bring many benefits to network professionals working with the cloud as cloud service providers typically will have some RESTful API in place to allow consumers to interact with their cloud resources through the API. This would be useful for them as people working to manage and maintain the cloud services in organizations are then able to automate certain tasks and integrate cloud services into their applications with ease.

REST also brings the benefit of being better in terms of scalability, which is a huge benefit to developers of SaaS software. The benefits that the scalability of REST brings to developers are that it's easy to optimize and scale applications accordingly. This means that they could add more resources if needed and distribute it to accommodate for higher loads, the statelessness of REST also brings the benefit for more specific types of software (like Microsoft 365 and Google Suite) as these days these services allow for multiple users to be working on the same document as there wouldn't be a reliance on a session state.

The use of REST brings even more benefits to SaaS developers since it promotes decoupling the client and the server. This would allow SaaS developers to make changes to the software where needed live and not need to do a full restart of things to push it as these changes would be able to be made on different components independently and wouldn't affect the entire system if an update or change was pushed.

Software-Defined Networking in the Industry

Software-defined networking (SDN) has been a concept since the late 90s and is a newer approach to networking that uses software-based controllers or APIs to communicate with underlying hardware infrastructures and direct traffic within a network [11]. SDN focuses on four main features, separation of the control plane from the data plane, a centralized controller and view of the network, open interfaces between devices in the control plane and the data plane and programmability of the network by external applications [12].

In comparison to the more traditional ways of networking, SDN separates the control plane from the data plane which gives a few advantages. Due to this, the SDN controller can view the complete network which allows for flow to be optimized which means in the long run that you'll have more flexibility and scalability [12]. SDN also allows for dynamic adaptability, compared to traditional networks where everything must be manually adjusted, SDN can change network configurations based on what changes within the network, which will allow for optimal performance. In the diagram below, you'll be able to see how the control plane and data plane becoming one works.

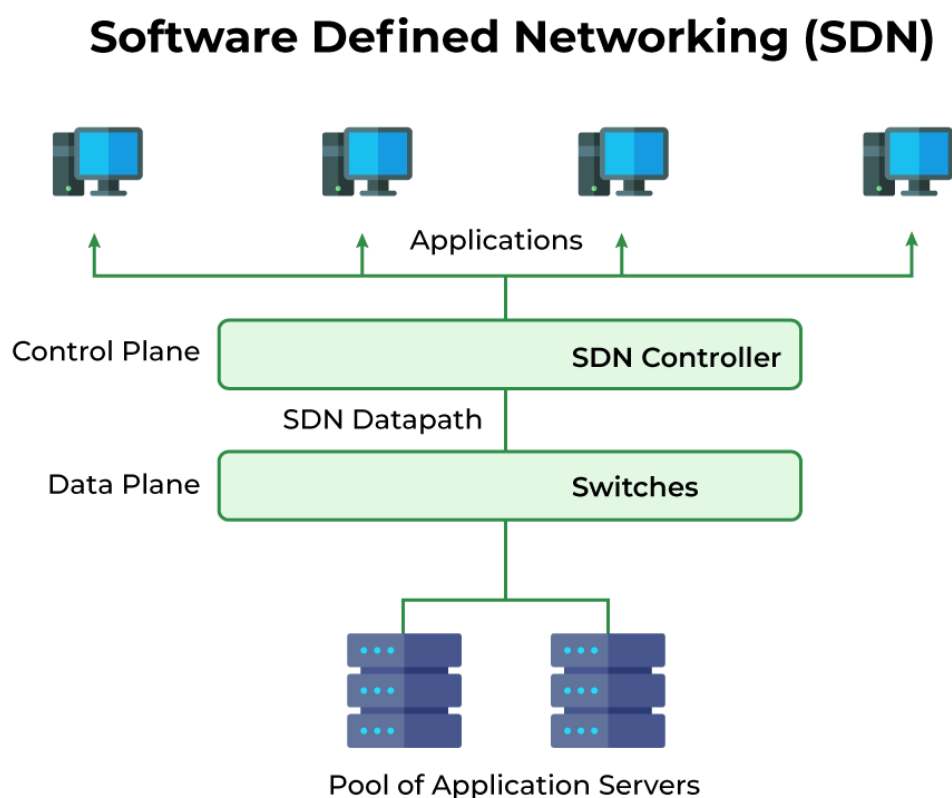


Figure 3 Diagram of Software-Defined Networking [13]

Taking us back to why this would be adopted over traditional networks within the industry, it's mostly been adopted since it's had a huge impact on overcoming challenges with traditional networks. SDN has addressed the need for greater flexibility within networks because of the decoupling of the control and data planes and allows for adjustments to happen pretty much completely automatically when needed due to perhaps increased load, changing requirements or changes within the network itself. This reduces the need to rely on configuring things manually, which also reduces the amount of human error that could occur while configuring the server and could make automatically deploying a new server much easier.

Conclusion

Reflecting on everything that's been discussed throughout the course of this paper, the shift from the more traditional ways that networking has been done to more cloud-based solutions has been extremely effective, both for the end users and for organizations. It's completely changed the way we work, store and access our data and even changed the job roles that have been set in stone for years for professionals. The introduction of SaaS has made things so much easier for people as they can now access their software from not just their home computer, but from their phones or tablets, which completely removed the struggle that people used to have with installing software and getting errors or then finding out that the software doesn't run on their machine.

IaaS has proven itself in being a driving force in moving the tech world forward, allowing organizations that before would have struggled to start their own networks or may have not had the funds to finally tap into that market and scale up their businesses without being too of a burden and too expensive. I don't believe cloud computing will be going anywhere anytime soon, it's even expanded into other areas now like gaming, you can literally stream games now it's crazy. I don't think it'll also be slowing down anytime soon, with as seen in Figure 2, it should be almost a half a trillion-dollar industry by then.

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