KNOWLEDGE PACK

Cloud for Education

WORLD BANK GROUP
Education

EXPLORE

KNOWLEDGE PACK

CLOUD FOR EDUCATION

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INDEX

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Introduction

What is a KP?

Knowledge Packages (KPs) are short, pragmatic guides on individual topics within EdTech, meant to provide sufficient knowledge and understanding so that non-technical stakeholders can make key planning, design, and procurement decisions for education.

They can be used as a starting point for the planning of technology deployment to improve education, especially with education ministries.

About this KP

The primary purpose of this knowledge pack is to provide high-level knowledge and understanding of cloud computing for Education as a starting point for creating a cloud strategy that includes policy, planning and procurement decisions. This Knowledge Pack contains a main presentation and an APPENDIX that includes an FAQ to access details. NOTE: this KP is not prescriptive in terms of providing specific implementation or operational details.

What you can get out of this KP

- Help develop your cloud strategy.
- Sift through the confusion, chaos, and noise around cloud and reduce risk and increase likelihood of success with cloud.
- Apply proven practices to avoid reinventing the wheel and avoid common pitfalls and costly dead ends.
- Minimize costs of implementing cloud and get more value out of cloud.
- What to consider for a cloud RFP.

FAQ

After reading the main content of this KP, some questions might pop* :

- How did Cloud come about?
- Where does Cloud fit in the IT timeline?
- Why are services at the core of Cloud?
- What are the different types of Cloud Services?
- What are Infrastructure Services?
- What are Platform Services?
- What are Software and Data Services?
- What is Virtualization?
- Is Cloud the same as off-prem?
- Is Private Cloud the same as off-prem?
- What do I need to know about Cloud Security and Privacy?
- What regulatory and privacy issues should I be aware of?
- How do you mitigate Connectivity issues?
- What is involved with a current state assessment?
- What are examples of VGOs and use case scenarios?

*To know more about these questions and their answers, go to the FAQ available in the annex.

WHO are the main stakeholders ?

This Knowledge Pack is primarily for non-technical decision makers who are responsible for defining a cloud strategy and making decisions related to Cloud for education.

	RESPONSIBILITY
Task Team Leaders (TTL's) & Bank Project Managers (non-technical)	• Understand general Cloud concepts so as to evaluate and advise on Client requests or requirements and to help design and supervise projects with Cloud components.
Ministries of Education (MoE) (non-technical Leadership, Managers)	• Use KP to make key planning, design, and procurement decisions related to Cloud components in an education program or digitization and transformation project.
Large Education Institutions e.g. Universities (non-technical Leadership, Managers)	• Use KP to make key planning, design, and procurement decisions related to Cloud components in an education program or digitization and transformation project.
Technical staff in Education (Technical)	• Use the KP to understand how Cloud relates to solving education challenges. Gain an overview of cloud technologies where capacity is lacking.
Donors, NGOs and Other Partners (non-technical)	• Use KP to align with Bank EdTech programs and establish a common EdTech framework.

WHY is this KP designed ?

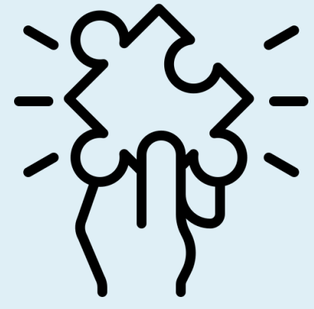
PROBLEM STATEMENT

BUILDING SCHOOLS OF THE FUTURE AND THE POTENTIAL OF CLOUD

COVID pandemic has shown the need to build resilient education systems with blended or hybrid learning an integral part of the education system.

The School of the Future, is where students learn anytime, anywhere, teachers are continuously supported and pedagogical approaches are personalized and adapt to the level of the students

The Cloud is a key enabler of flexible resilient education systems.



We can't talk about scaling interventions that benefit from technology without talking about the cloud.

WHY is this KP designed ?

WHY ARE EDUCATION SYSTEMS AROUND THE WORLD MOVING TO CLOUD?

Build flexible and resilient Education Systems

Learning Management Systems (LMS), Virtual Classrooms, Remote Learning Systems and Digital Content can be **hosted in the Cloud** and **scaled up rapidly** in the event of School Closures as was the case during COVID pandemic. In addition, students can access learning resources in the Cloud anytime, anywhere with an internet connection.

Personalizing learning and remediation

Cloud technologies can be used to host Adaptive Learning Systems and to process and analyze large amounts of **data** to **personalize learning**. In addition, students can access learning resources in the Cloud anytime, anywhere with an internet connection. Cloud technical can enable solutions to recover learning losses at scale such as online tutoring.

Enable Data collection and analytics for system improvements

Cloud technologies can be accessed by all schools and administrators to collect **data on any device** with an internet connection and to **analyze this data in real time** to provide insights and support evidence-based decision making e.g. identifying “at risk” students falling behind or likely to drop out.

Continuous Teacher Professional Development at Scale

Online and blended learning systems as well as collaborative platforms hosted in the Cloud can be used to support **large scale** continuous professional development of teachers.

Reduce IT complexity and costs to focus on education outcomes

Schools can develop and deploy new education technology solutions without having to invest in complex IT infrastructure upfront and can instead **focus on serving students’ needs**.

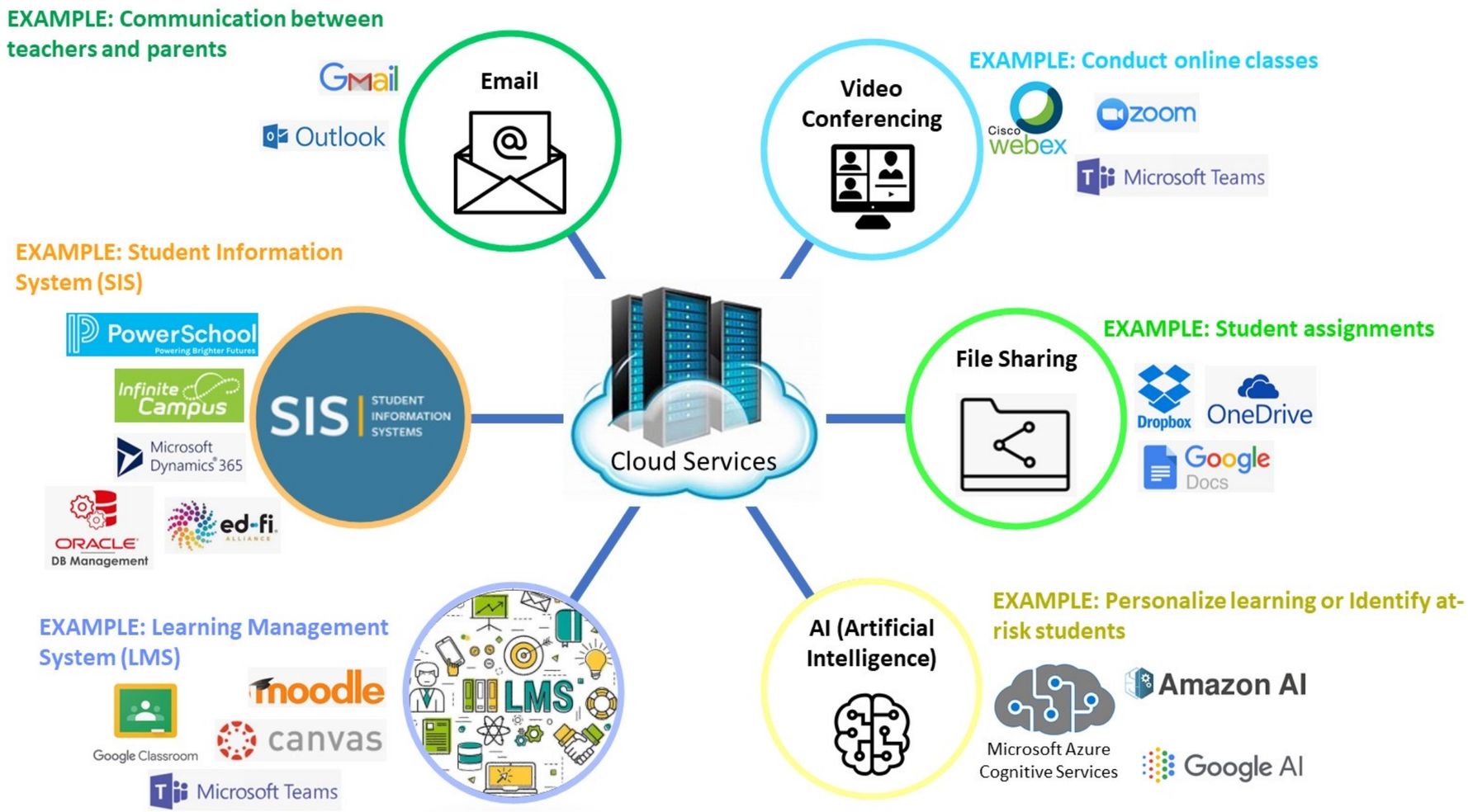
Save time for teachers

Increasingly complex machine learning algorithms can mark student assessments to provide instant student feedback and **free up teacher time** to focus on student learning.

WHY is this KP designed ?

USE CASES

EXAMPLES OF EVERYDAY PUBLIC CLOUD SERVICES FOR EDUCATION



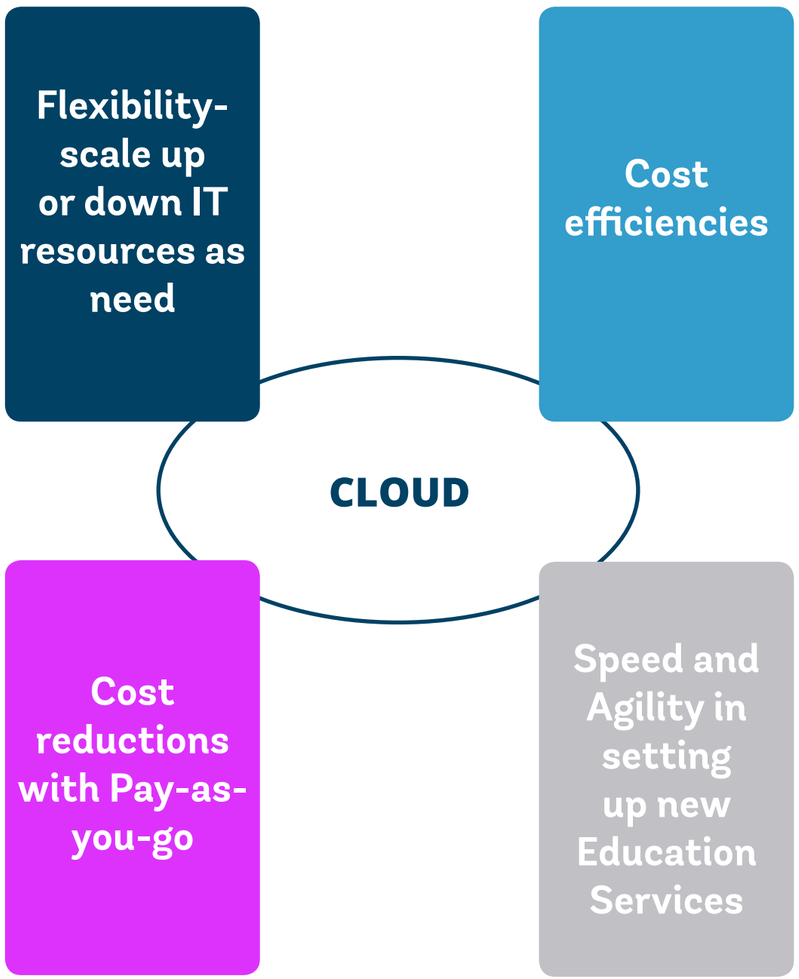
WHY is this KP designed ?

BENEFITS

CLOUD SIMPLIFIES IT SO THAT EDUCATION SYSTEMS CAN FOCUS ON TEACHING AND LEARNING

IT resources scaled up or down on demand without costly and time-consuming investments in additional physical IT infrastructure.

EXAMPLE: During high-stakes examinations, resources are automatically reallocated from other less critical operations. Even in a disaster, IT resources can automatically be dispatched from special disaster recovery (DR) resources to step-in and keep things running.



Sharing infrastructure across departments or even across ministries means that costs can also be shared. With a public cloud provider, infrastructure is shared across multiple subscribers.

EXAMPLE: A public cloud email service, such as Gmail or Outlook, can be offered at very low cost since that service may be shared with many millions of subscribers.

Like an electricity utility, you only pay for the services you use (i.e. OpEx) versus a fixed cost (i.e. CapEx) of having to purchase yourself.

EXAMPLE: When teachers and students are not using the collaboration service, you are not paying for it.

When a service is developed, the underlying resources such as servers, storage, databases, etc. are provisioned (i.e. setup) and managed automatically so that you focus on education NOT technology.

EXAMPLE: If there is a new education application developed or purchased, it can be deployed rapidly without spending time worrying about servers and other resources.

WHAT are the potential solutions?

CORE CONCEPT

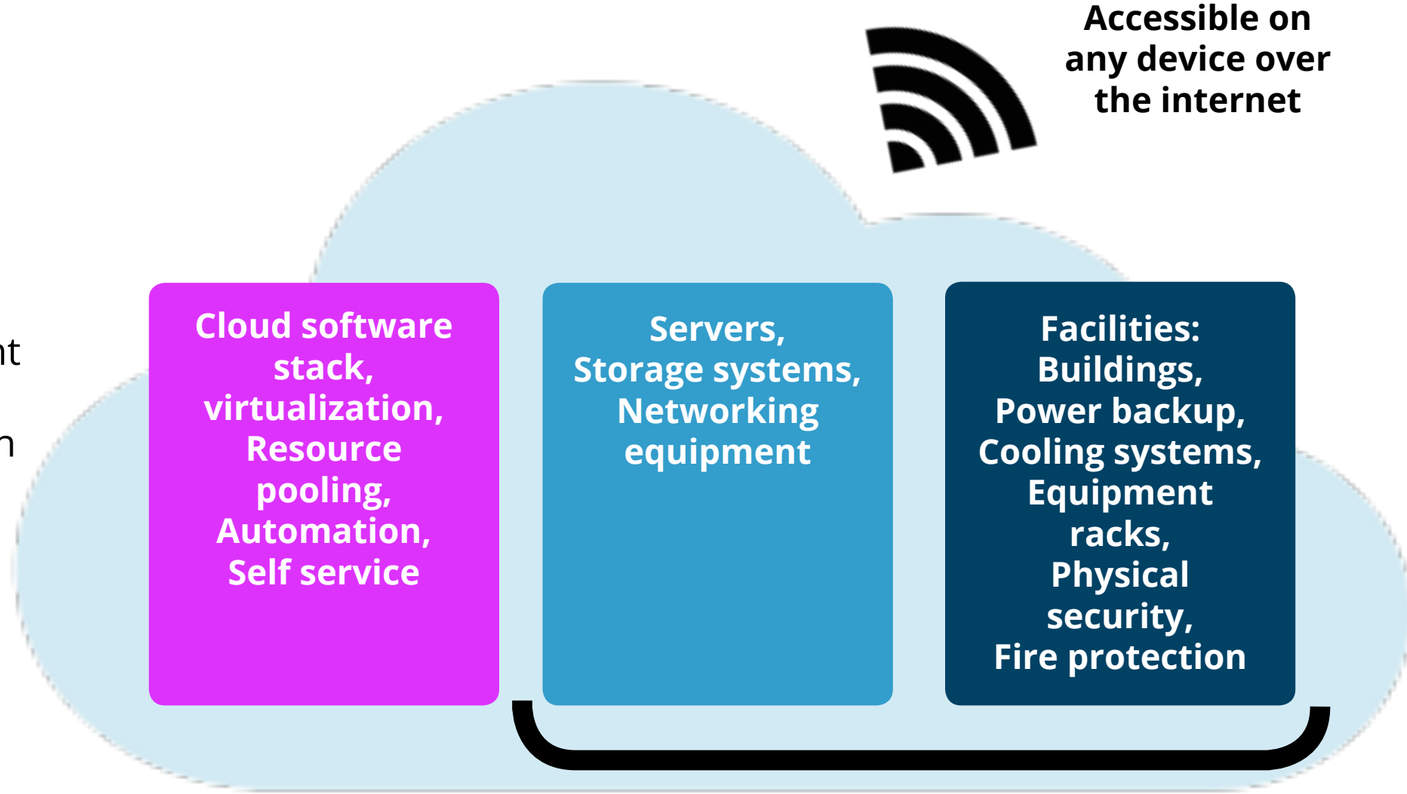
WHAT IS CLOUD IN A NUTSHELL?

"Cloud" refers to a Data Center* connected to the internet in which IT resources such as networks, servers, storage and applications are delivered on-demand, are scalable (elastic) and as services over the internet. A Data Center is a building or part of a building housing Servers, data storage, networking and other equipment and applications to process, store and share data.

All Data Centers are moving to the Cloud by adding special software to the IT infrastructure to:

- Virtualize and pool the IT resources- (What is virtualization?)
- Automate the management of the IT resources with limited human intervention
- Make the IT resources available to users on demand in a self-service model
- Elastically (and automatically) add or remove resources as needed
- Deliver resources as services over the internet

This means you can treat IT resources almost like a "utility" with "pay as you go" pricing.



DATA CENTER

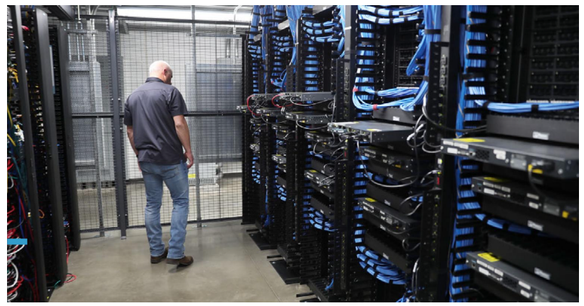


Photo : Data center from Data center Knowledge

WHAT are the potential solutions?

STRUCTURE OF SOLUTIONS

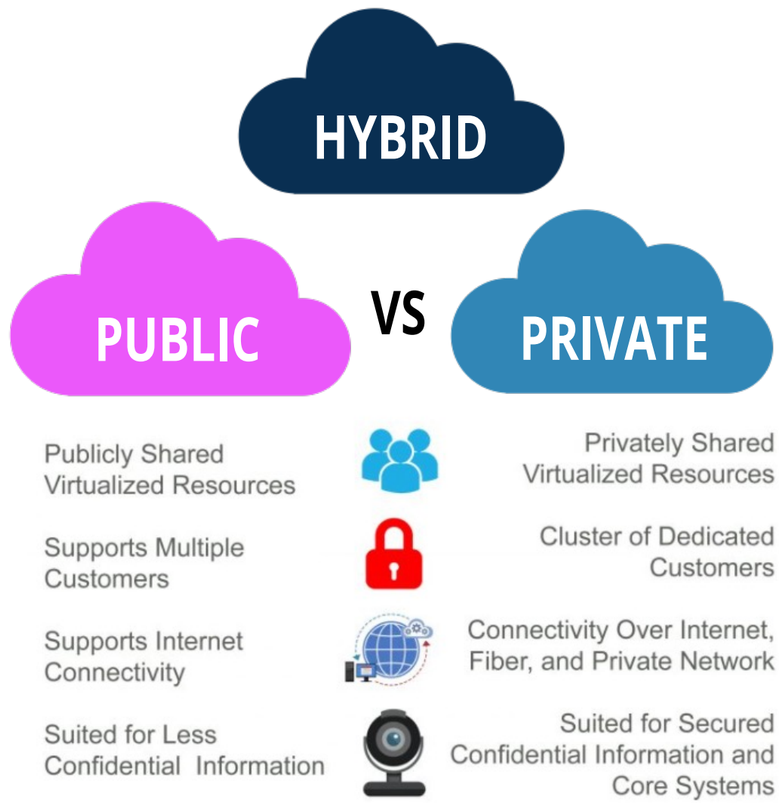
TYPES OF CLOUD

There are 3 types of Clouds depending on who owns, hosts and manages the underlying data center infrastructure:

Private Cloud: An organization owns and manages its data center equipment often on the premises of the organization (on-premise) or a 3rd Parties Premises (Co-location or Virtual Private Cloud) or for the benefit of its employees and customers only e.g., a ministry of Education Data Center can offer Cloud services for all education institutions in their country.
The main advantage of a private cloud is full control over the infrastructure and services.

Public Cloud: An organization does NOT buy, own and manage their data center instead acquiring services from companies called Cloud Service Providers (CSPs). The biggest CSPs include Microsoft (Azure), Google (Google Cloud Platform) and Amazon (Amazon Web Services or AWS).
The main advantages with using a Public CSP is that i) an institution does not have to buy, own and manage their own data center thus avoiding high start up or expansion costs and ii) the institution can scale resources rapidly and easily when extra/ additional capacity is needed.

Hybrid Cloud: combines a private cloud service and a public cloud service to provide maximum benefits: full control over private cloud and often ability to scale capacity rapidly on the public cloud when required.



Source: Adapted from University of Illinois

WHAT are the potential solutions?

STRUCTURE OF SOLUTIONS

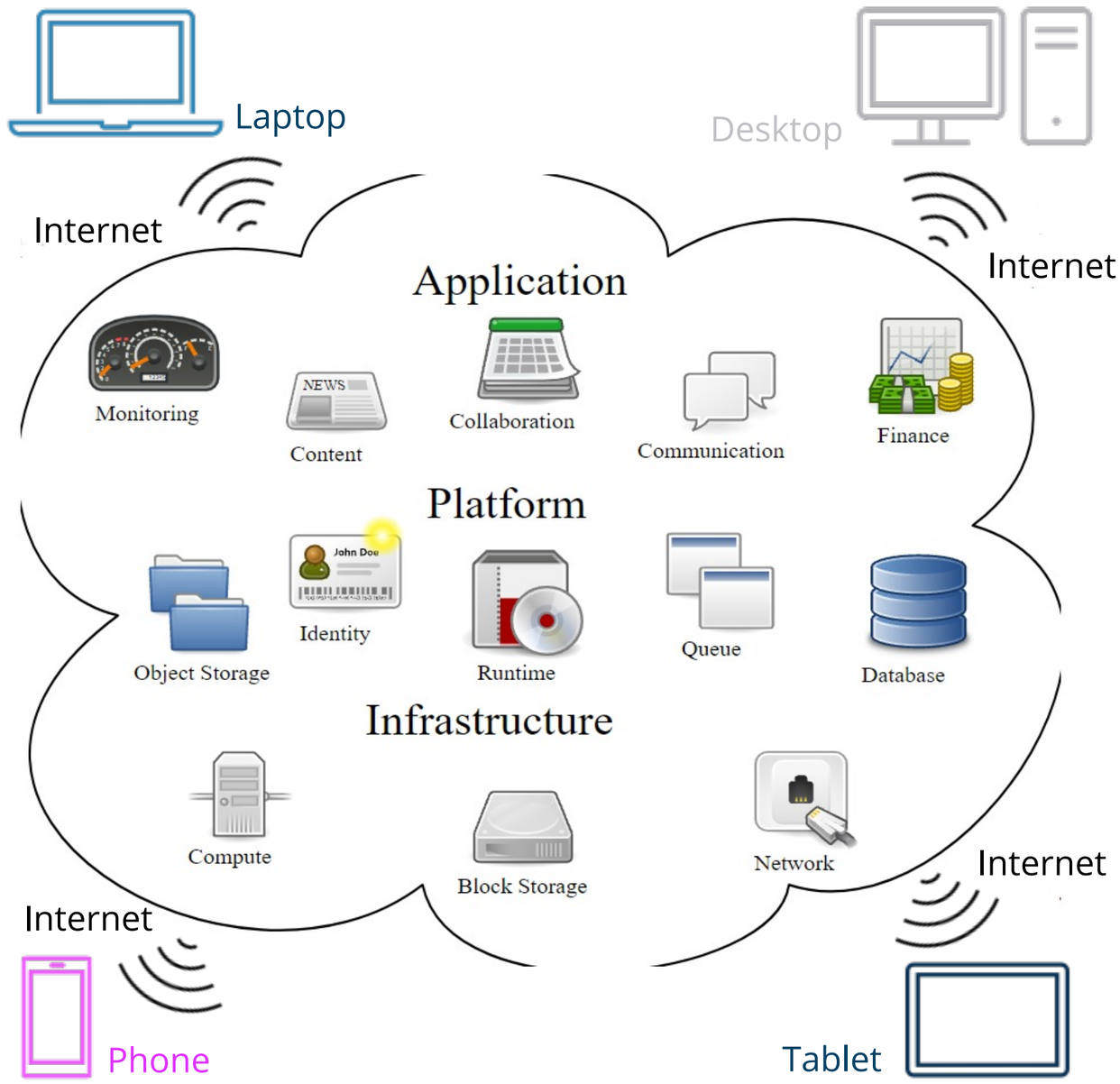
CLOUD SERVICE MODELS

Cloud services come in 3 main "service models" which can be thought of as "layers":

Infrastructure as a Service (IaaS): is the basic cloud service that provides access to servers (compute), storage space and networking resources over the internet. For public clouds, it eliminates the need for organizations to build their own data centers. For Private Cloud, it eliminates need for every organization's department or branch to have their own data center.

Platform as a Service (PaaS): combines compute, storage and networking and usually operating systems and databases. It is targeted at developers allowing them to focus on developing, deploying and managing applications without worrying about underlying infrastructure.

Software as a Service (SaaS): provides a completed application that is run and managed by the service provider. It allows organizations to focus on serving its customers and not on IT. Popular examples of SaaS are Gmail and Microsoft Office 3.

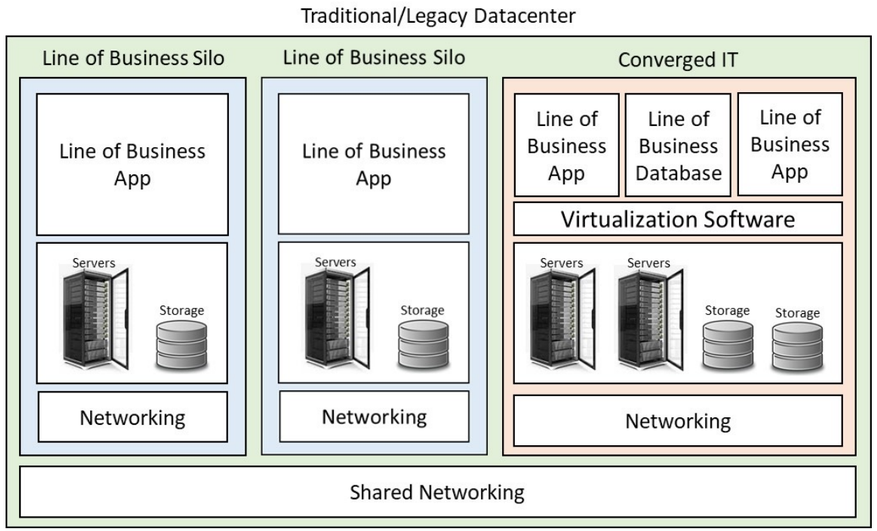


Source: Adapted from Wikipedia image Created by Sam Johnston

WHAT are the potential solutions?

CHALLENGES AND TRADE-OFFS

BIG TYPICAL MISTAKES AND TRADITIONAL IT CHALLENGES THAT CLOUD OVERCOMES



42% of Capital Costs: Hardware, software, disaster recovery arrangements, uninterrupted power supplies, and networking.

58% of Operational Costs: Heating, air conditioning, property and sales taxes, and labor costs.

CHALLENGE	IMPACT
Silos (each department has own servers/ data center)	Grossly inefficient duplication of resources
Manual Provisioning of Hardware (HW) and Software (SW)	Very slow, costly, and unreliable
Difficult to Grow and Plan for Peak	Inefficient and can't keep up with demand and high-demand events such as national exams
High & Hidden Total Cost of Ownership (TCO)	So many unknown and hidden costs
Obsolete Hardware (HW) and Software (SW)	As soon as you buy HW or SW it becomes obsolete and costly to support with slow upgrade cycles
Poor Reliability	When weather gets hot, servers start crashing which is disruptive to teaching and learning
Poor Availability and Accessibility	Teachers and students can't access using any device from anywhere and have to remember a bunch of usernames and passwords

WHAT are the potential solutions?

CHALLENGES AND TRADE-OFFS

REALITY CHECK: IF CLOUD IS SUCH A BIG DEAL, WHY ISN'T EDUCATION ADOPTING IT IN A LARGE WAY?

While Education Systems increasingly use Cloud Services, there is still a lot of traditional IT investments going on especially in LMICs.

POINT	COUNTERPOINT
1. "Sunk Cost Effect": Significant investment in existing, traditional IT infrastructure	In the long run, cloud has strong economic and efficiency advantage over traditional IT.
2. Traditional IT Culture and Vendor Relationships: Traditional IT mentality and existing relationships with vendors	Most Vendors increasingly support migration to Private Cloud as well as Hybrid Cloud. Cloud has strong economic and efficiency advantage over traditional IT.
3. Data Sovereignty, Security, and Privacy: Government policy or regulation requires in-country	Develop Private Cloud on-prem or using a CSP with an in-country cloud datacenter.
4. CapEx vs. OpEx: (Public) Cloud requires shift to Opex. Difficulty in shifting policy, budget, funding to OpEx	Develop Private Cloud. Consider OpEx as it eliminates the need for large upfront CapEx investments.
5. Knowledge and Skills: Lack of knowledge and skills for implementing and operating cloud	There is a significant global knowledge base and many certification programs in many different languages are available.
6. National Economic Interests: Keep investments within the country by using local vendors	Focus on building greater upstream value in education delivery vs. building IT infrastructure.
7. Connectivity: High Internet costs when accessing a CSP	Use on-prem Private cloud or at least hybrid cloud services.
8. FUD: Fear of not having control of the infrastructure, **Uncertainty** of costs and/or runaway costs, **Doubt** that cloud will really deliver on its promise	CSP's offer tools to manage costs and optimize resources, as well as measure ROI.

WHAT are the potential solutions?

WHAT HAS BEEN DONE IN OTHER COUNTRIES

SOME GOVERNMENTAL ARE DEPLOYING NATIONAL EDUCATION CLOUDS

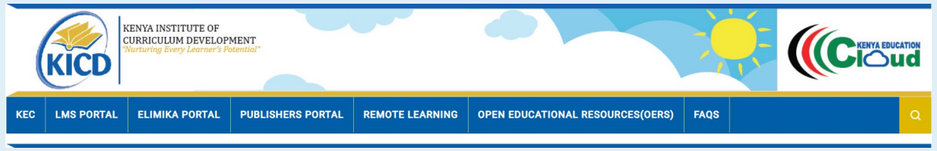
Many countries already use Cloud Services particularly Software as a Service (SaaS) in areas such as Email, Collaboration and video conference systems, Financial Management System, Learning Management Systems and Education Management Information Systems. The pandemic accelerated the use of such SaaS solutions.

MINISTRY OF EDUCATION
THE PEOPLE'S REPUBLIC OF CHINA
国家中小学网络云平台

China the National Online Cloud Classroom launched as the Start of COVID. It is a free online learning platform for primary and secondary school students studying at home during the COVID-19 outbreak.

eba

Turkey's EBA is a Cloud based online platform that was extensively used for remote learning during COVID pandemic.



Kenya Education Cloud for pre-primary, primary and secondary school students providing LMS and Content resources for teachers and students on Hybrid Cloud.

GÉANT CloudServices
CONNECTING RESEARCH AND EDUCATION TO THE CLOUD

European Research and Education Network (GEANT) offer cloud services for European Research and Education Institutions.

WHAT are the potential solutions?

WHAT DOES THE MARKET LOOK LIKE?

PRIVATE CLOUD PROVIDERS

WHO OFFERS CLOUD FOR EDUCATION IN THE PRIVATE SECTOR?

Most “traditional enterprise” hardware and software vendors offer infrastructure and software for private and hybrid cloud deployments. Increasingly these companies also offer a “managed service” private cloud on your own premises:

Hewlett Packard Enterprise

- Hewlett Packard Enterprise offers HPE Private Cloud Services.

DELL Technologies vmware

- Dell Technologies offer solutions for K12 Data infrastructure and cloud and Higher Education Solutions. VmWare, owned by Dell, offers digital infrastructure for K12 and Higher Ed. Its software can enable cloud services for education.

HUAWEI

- Huawei offers several solutions for education and a hybrid cloud stack for governments and enterprises.

Red Hat

- RedHat’s offers several products to create a private cloud within your existing data center based as part Cloud Suite.

Note: These are only examples of providers. Clients should check for local and international providers in their own countries.

WHAT are the potential solutions?

WHAT DOES THE MARKET LOOK LIKE?

PUBLIC CLOUD PROVIDERS

WHO OFFERS CLOUD FOR EDUCATION?

Almost all public cloud providers have education cloud services. Many of the top public CSPs also provide options for Private & Hybrid Cloud. Examples include but are not limited to:

Google

- Google Cloud for Education includes Google Workspace providing applications such as Google Classroom and Google Meet. Google Anthos is hybrid cloud solution running on leading server vendor Hardware.

Microsoft

- Microsoft has a suite of education cloud solutions including Microsoft Teams for remote learning and Office 365 Education for productivity applications. Azure Stack Hub is Microsoft's hybrid cloud solution.

aws

- AWS Cloud for Education provides several solutions including back-end data management to virtual desktops. AWS Outposts is AWS's hybrid cloud solution.

ORACLE

- Oracle Cloud for Education provides solutions for k12 to Higher Education including Enterprise Resource Planning (ERP), Human Resources (HR) and financial management and EMIS applications. Oracle Cloud@Customer brings all of Oracle's public cloud services into the organizations own data center.

IBM

- IBM Cloud for Education offers include an Applications Lab and SPSS Software on Cloud. IBM Cloud Satellite provides hybrid cloud capabilities.

zoom

- Zoom popular during COVID for remote learning is a SaaS offering.

moodle

- Moodle offers a Cloud based LMS on Moodle Cloud.

Note: These are only examples of providers. Clients should check for local and international providers in their own countries.

HOW to implement next steps ?

STRATEGY

WHAT ARE THE STEPS IN CREATING A CLOUD STRATEGY?

1. Assemble Cloud Team
Assemble cloud team and acquire key skills necessary to make business and technical tradeoff decisions.

2. Assess Current State
Assess your current state in terms of existing infrastructure, process, accessibility, stakeholders, etc.

3. Determine VGOs
Define your future state for cloud in terms of vision, goals, and objectives (VGOs)

4. Identify Use Case Scenarios
How teachers and students will be using your cloud solution to achieve VGOs.

5. Determine Cloud Solution
Determine your cloud solution based on VGOs, Use Case Scenarios.

6. Create Solution Roadmap
How you go from your current state to your desired future state using cloud services.

7. Execute Roadmap
Execute roadmap one step at a time. ACM (Adoption and Change Management).

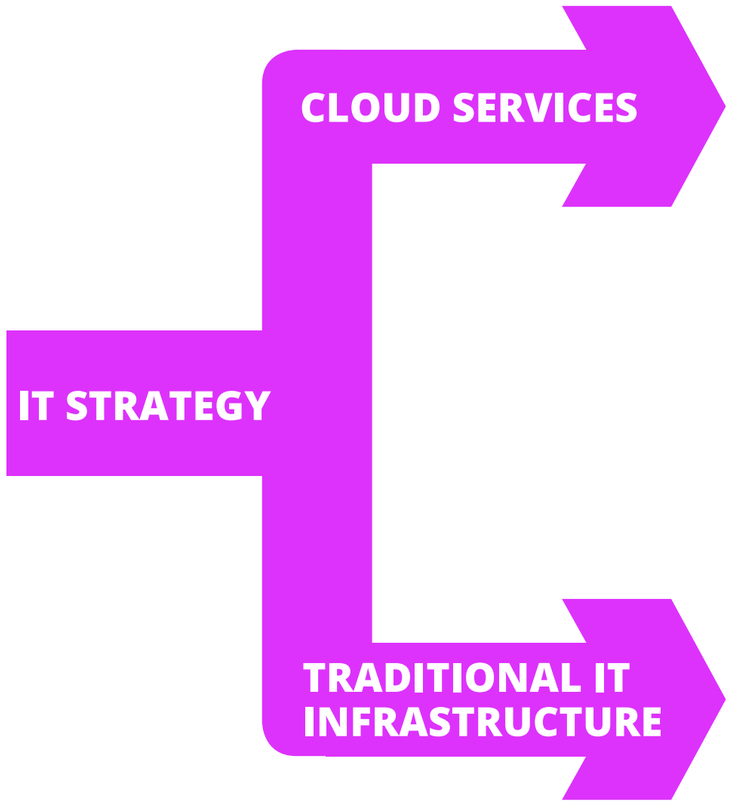
8. Adapt, Improve & Sustain
Adapt and adjust based on what is working and what is not working, as well as new or updated VGOs.

Note: Refer to "Journey to the Cloud: Improving Government Services through Cloud Solutions", section 4.2 on "decision-making level".

HOW to implement next steps ?

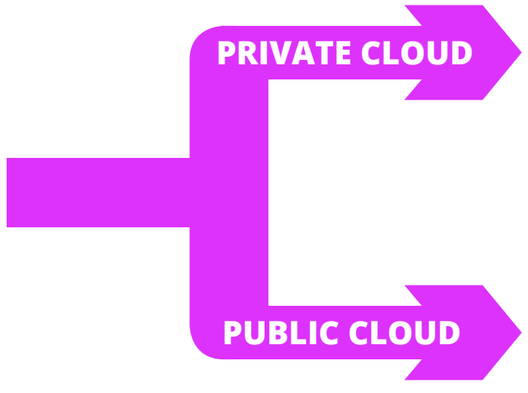
STRATEGY

OPTIONS FOR YOUR IT STRATEGY



Cloud Services

This means developing and implementing a strategy for providing Cloud services to your users. Your main options for providing cloud services are:



Become your own provider of cloud service.

AND/OR

Procure cloud services from a CSP.

Traditional IT infrastructure

Although, it's possible to have traditional IT infrastructure along side cloud; it's more advantageous to migrate your existing traditional IT infrastructure to cloud.

Benefits of moving to the cloud

- Reduced costs- from automation to self service and eliminating capital costs if using public Cloud
- Scalability- scale up and down quickly as needed
- Rapid Start Up- provide services rapidly without having to procure, setup and provision infrastructure
- Reduce energy- public cloud can reduce energy usage by up to 90%*

**Source: "Journey to the Cloud: Improving Government Services through Cloud Solutions", World Bank*

HOW to implement next steps ?

STRATEGY

HOW DO YOU DETERMINE THE RIGHT CLOUD SOLUTION?

The choice between a public, private or a hybrid cloud deployment depends on a variety of factors and is rarely either/or situation in real world.

PRIVATE

Private Cloud suitable for public sector entities:

- Working within a **restrictive regulatory framework** e.g. data residence requirements
- Working with **“top-secret data”**
- Can afford to **continuously invest** in high performance technology and
- have **qualified IT personnel** available

HYBRID

Hybrid Cloud is suitable for organizations facing various security, regulatory and performance requirements with the need to have scalable, agile, elastic resources

PUBLIC

Public Cloud is most suitable when:

- There is a focus on cost efficiency with **no upfront capital costs,**
- **unpredictable demand peaks**
- **Need for advanced features** for instance AI-enabled security

Source: “Journey to the Cloud: Improving Government Services through Cloud Solutions”, World Bank

HOW to implement next steps ?

STRATEGY

KEY FACTORS IN DETERMINING YOUR CLOUD SOLUTION - PRIVATE OR PUBLIC

Use Case Scenarios
What applications and how they will be used is a key determinant.

- Mature SaaS applications like website hosting, Email, Collaboration tools for remote learning, Video conferencing and Learning Management Systems are likely to be best served by Public Cloud.

Environment
Includes connectivity, existing infrastructure, supplier ecosystem.

- If there are no local Public Cloud Data Centers in the country and there is poor connectivity, use of public cloud could be impacted. Consider Private Cloud.

Budget/Funding
Public Cloud uses a “pay as you go” model.

- “Pay as you go” model eliminates any large upfront costs. However, this requires a change in budgeting from currently common CAPEX model to OPEX models. Many MoEs and donors are hesitant to fund OPEX. If you can’t use OPEX, consider Private Cloud and use CAPEX.

Skills/Capacity
Private/ Hybrid/ Public Cloud requires skilled IT personnel.

- Since Cloud is still relatively new, many Ministries in low-income countries lack these skills and this could impact speed of migration. Invest in skills upfront. Many Cloud providers offer training courses at various levels for civil servants who want to upskill on cloud and associated topics such as cybersecurity, big data and artificial intelligence.

Data Control or Sovereignty
Some countries have laws restricting where citizens’ data can be stored.

- This may impact the choice of Cloud solution to adopt especially if there are no local public cloud providers.

Legacy Systems
Having no large legacy system makes it easier to adopt Cloud.

- Cloud enables these organizations to “leapfrog” to the latest technology. Having large legacy systems leads to “sunk costs” fallacy.

HOW to implement next steps ?

TEAM

THE RIGHT SKILLED TEAM IS KEY TO CLOUD SUCCESS

Before you embark on your cloud journey, it is critical to first assemble and build the capacity of your team.

The team could include some or more of the following roles:

- **IT managers-** need foundational Cloud and Business knowledge
- **Project managers-** need foundational cloud knowledge
- **Solution Architects-** evaluate the organizations business needs and design IT systems to respond to these needs
- **System Administrators-** who look after Cloud infrastructure
- **Cloud Developers-** design, develop and maintain applications in the cloud
- **Data Engineers, Data Scientists, AI specialists-** manage data, use machine learning and Artificial Intelligence to solve business needs
- **Security engineer-** manages security of cloud infrastructure and applications

It is recommended that once the team is assembled, the team can take training and certification courses on Cloud technologies from any of the major Public Cloud Providers such as Amazon, Microsoft, Google and others.

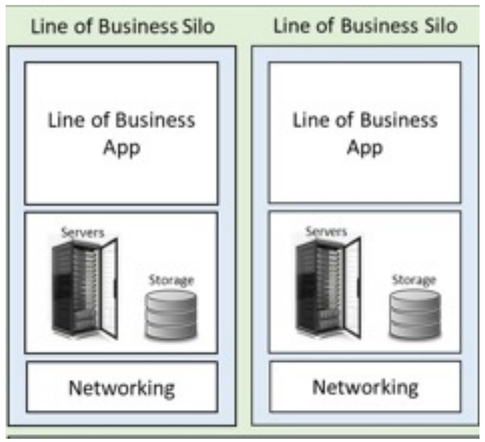
Some countries or universities have partnered with global Cloud providers to offer university level courses to increase the number of skilled cloud professionals in the country.

HOW to implement next steps ?

PRIVATE CLOUD

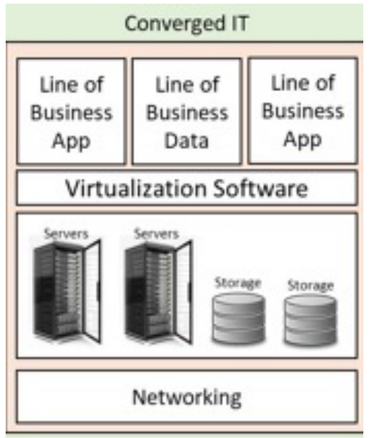
TYPICAL PATH TO PRIVATE CLOUD

Traditional IT/ Data Centers



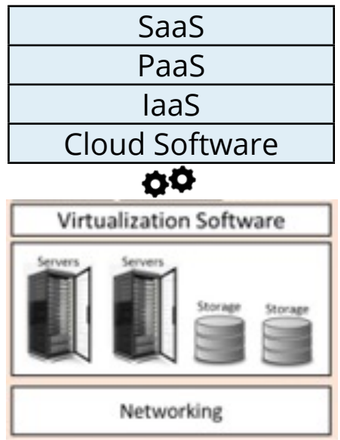
Traditional IT has silos of infrastructure and usually multiple data centers/ server rooms per department. Start by taking a full inventory of IT resources.

Consolidate and virtualize compute, storage, networking



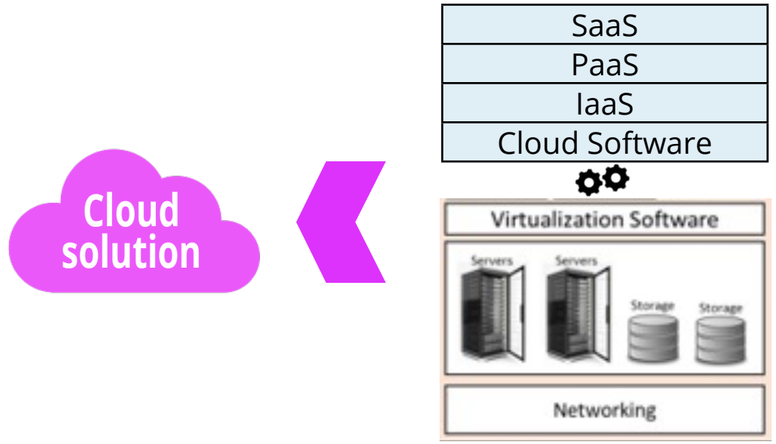
First step is usually to consolidate servers into one or fewer data centers, standardize servers (including buying new servers to replace old ones), simplify network and add virtualization software to virtualize computer, storage and networking.

Transform to Private/Hybrid Cloud with Automation, Orchestration and Self-Service



Add Cloud Management Software for resource pooling, orchestration, automation and self-service. Cloud software can enable private and hybrid cloud services.

OR start with Greenfield Private Cloud with pre-integrated solution



Greenfield start is ideal for organizations with no legacy systems or where legacy systems are mostly end of life.

HOW to implement next steps ?

PRIVATE CLOUD

CONSIDERATIONS FOR PROCURING PRIVATE CLOUD

SEPARATE LOTS

It is good practice to have separate lots for 3 key deliverables in a Request for Proposal (RFP) depending on your needs. Bidders can bid on one or more lots.

Lot 1- Data Center Facilities

- This includes building/ refurbishment, power systems, cooling systems and racks
- Can also use a 3rd party's facilities (co-location)in which case you "rent" the facilities OR procure a Virtual Private Cloud infrastructure run by a Cloud Service Provider in their own facilities.
- "Containerized" solutions are available. These are usually ready to deploy containers with power, cooling systems and racks built into the container

Lot 2- Servers, storage and networking equipment and Cloud Software

- Sold by the manufacturer or by a certified reseller
- Increasingly pre-integrated and pre-configured systems are available from many manufacturers including from public Cloud Service Providers
- Some manufacturers offer these pre-integrated solutions as a service. Solution is installed in your data center or in the Providers data center (co-location or Virtual Private Cloud) and usually managed by the manufacturer/ reseller and you pay a recurring fee

Lot 3- Consulting services

- Includes Planning, Architecture Design, Migration, Management, Support, Quality Assurance, Security, Training

SERVICE MODELS

- Requires a change in mindset of IT personnel as private cloud means "self-service or self-provisioning model which traditional IT views as losing control ii) other departments who have to give up their own infrastructure
- Change in budgeting at organization level as private cloud can come with a "chargeback model". Other departments are buying a service from internal private cloud

HELP DESK

IT will have to set up robust helpdesk for users. Can be a combination of phone, email and self-service models.

IT SKILLS AND CERTIFICATIONS

Organization should consider training for IT personnel and equipping them with industry certification on cloud technologies

HOW to implement next steps ?

PRIVATE CLOUD

CONSIDERATIONS FOR PROCURING PRIVATE CLOUD

PHASE 1 (PILOT)

Start with a small simple project that will not impact operations.

- Identify the Hardware (HW)-(servers, storage, and networking) for a single app or monolithic silo that has low utilization is not business critical.
- Either procure from CSP or develop on-prem backup and/or disaster recovery of on-prem data.
- Select IT staff has basic cloud skills.

PHASE 2

Build your cloud foundation.

- Consolidate your Data Centers/ server rooms/ HW, Standardize Servers and Add Cloud Software **(Private Cloud).**
- Establish digital identities for administrator, teachers and students, then provision their accounts and assign appropriate licenses.
- Migrate all existing silos to IaaS, PaaS, and SaaS.
- Review all applications and determine which ones to move to CSP as SaaS.
- Select IT staff has advanced cloud skills.

PHASE 3

Adopt a Cloud-first Strategy.

- All new applications should be Cloud-ready and deployed to the Cloud.
- Robust Internet connectivity enables cloud to scale for all aspects of service delivery automation including user lifecycle management.
- IT staff have cloud skills to leverage advanced cloud features and technology for optimizing costs, performance, and security.
- Full DR in place with consistent policies and procedures.

HOW to implement next steps ?

PUBLIC CLOUD

BUYING PUBLIC CLOUD SERVICES

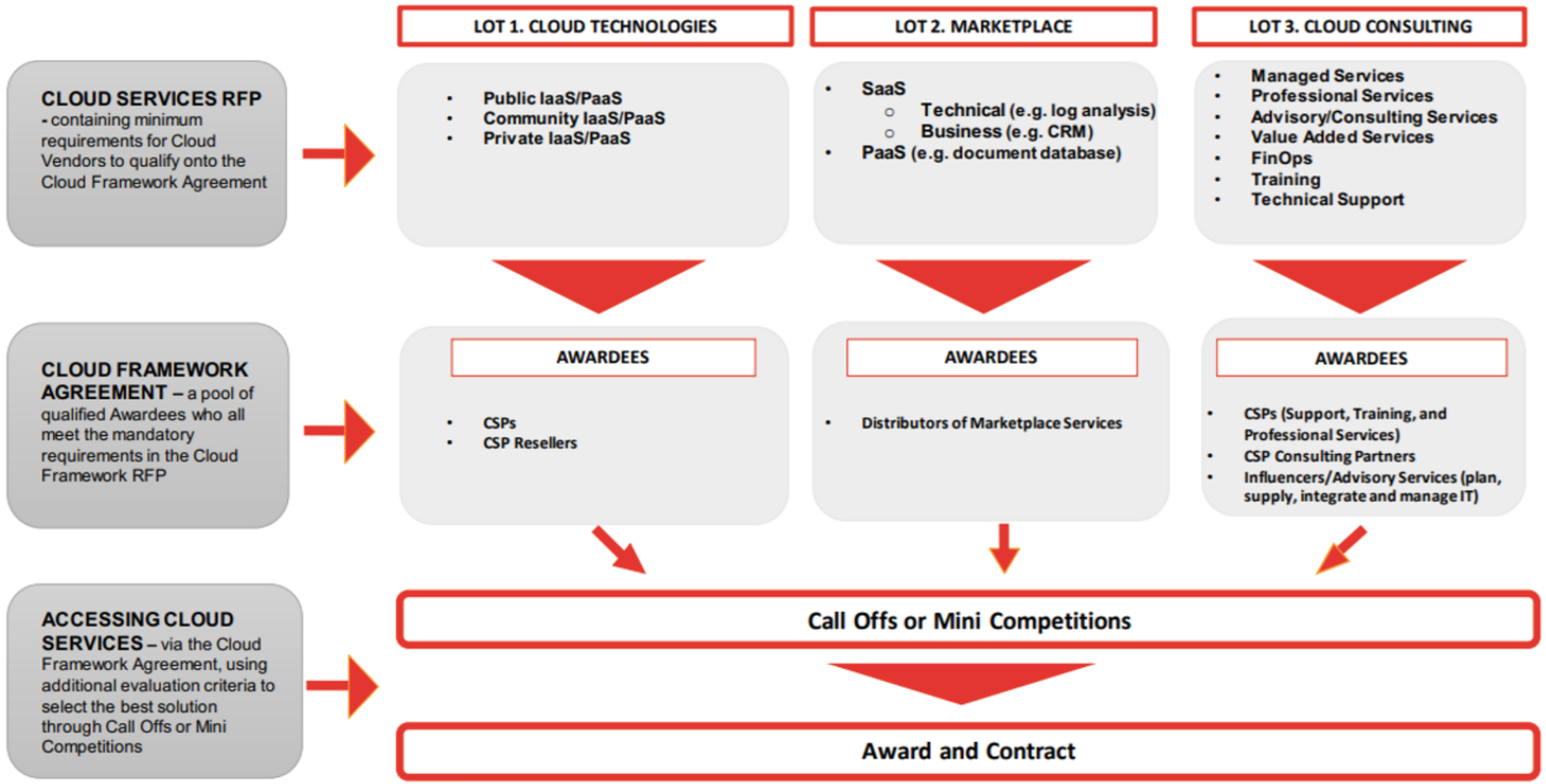


Figure 1 – A successful Cloud Services RFP is separated into 3 lots. Each lot contains Categories or 'types of offering' under the respective lot, to ensure technical and contractual fit to meet end user requirements when purchasing off the Cloud Framework Agreement.

Which service?
Decide between Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (IaaS)

Separate Lots
It is recommended to have separate lots for:
Cloud Technologies/ Infrastructure- IaaS/ PaaS
Applications- SaaS
Consulting Services- planning, deployment, migration, training

Framework Agreements*
Ministries of Education should consider framework agreements for entire education sector for efficiency and economy.

*Framework Agreement- "a multi-organizational award of a menu of clouds, from which eligible purchasers affiliated with the purchasing organization can acquire the cloud technologies and associated services that meet and suit their needs"-- Buying Cloud Services in Public Sector Handbook

Source: Buying Cloud Services in Public Sector Handbook - Including Sample RFP Language for a Cloud Framework Agreement.

HOW to implement next steps ?

PUBLIC CLOUD

UNDERSTANDING PUBLIC CLOUD PRICING

Most if not all public Cloud Service Providers (CSPs) publish their pricing on their websites. Check CSPs website for pricing.

PRICING FOR INFRASTRUCTURE (IAAS AND PAAS)

Cloud is “pay as you go” and you can cancel anytime. Pricing for infrastructure Is usually per hour or per second and is influenced by:

- Upfront commitments for amount of service (reserved services)- while service is pay as you go, having an upfront commitment for a minimum amount of services can reduce costs
- Commitment for length of time- in addition to commitments for amount of service, the length of commitment can impact pricing
- Higher consumption- the more you consume, the lower the per-unit cost can get (volume-based discounts)
- Specialized packages usually optimized compute, storage or network services for special applications

PRICING FOR SOFTWARE AS A SERVICE (SAAS)

- Is typically priced per month
- Is usually on a per user basis or tiered depending on “package” you choose
- Other pricing models for SaaS are flat rate, usage based or per feature, but these are less common
- Is influenced by volume discount or high value packages cost less

Pricing for IaaS and PaaS will involve determining:

- Amount of CPU resources
- Memory
- Storage type and amount
- Operating System used
- Region or where CSPs Data Center is located
- Bandwidth used
- Database required
- Level of performance (e.g. IOPS), reliability and availability required
- Single Tenancy vs shared infrastructure
- Pay as you Go vs Reserved/ committed services

Use public CSP Price Calculators to get a budget (and see how variables above influence price).

It is critical to track spending and adjust/ optimize variables as use the Cloud.

Conclusion

WHO

Key stakeholders are the **Ministry of Education IT departments, Senior management in Ministries of Education, teachers, students and private sector Cloud Service Providers (CSPs)**. Almost all public cloud providers have education cloud services. And most "traditional enterprise" hardware and software vendors offer infrastructure and software for private and hybrid cloud deployments.

WHY

Cloud can help improve education by **improving access and quality of education** while building a **resilient, flexible education system in cost effective ways**. Cloud **empowers you to focus on what matters most**: delivering education vs. building, maintaining, and supporting IT infrastructure.

WHAT

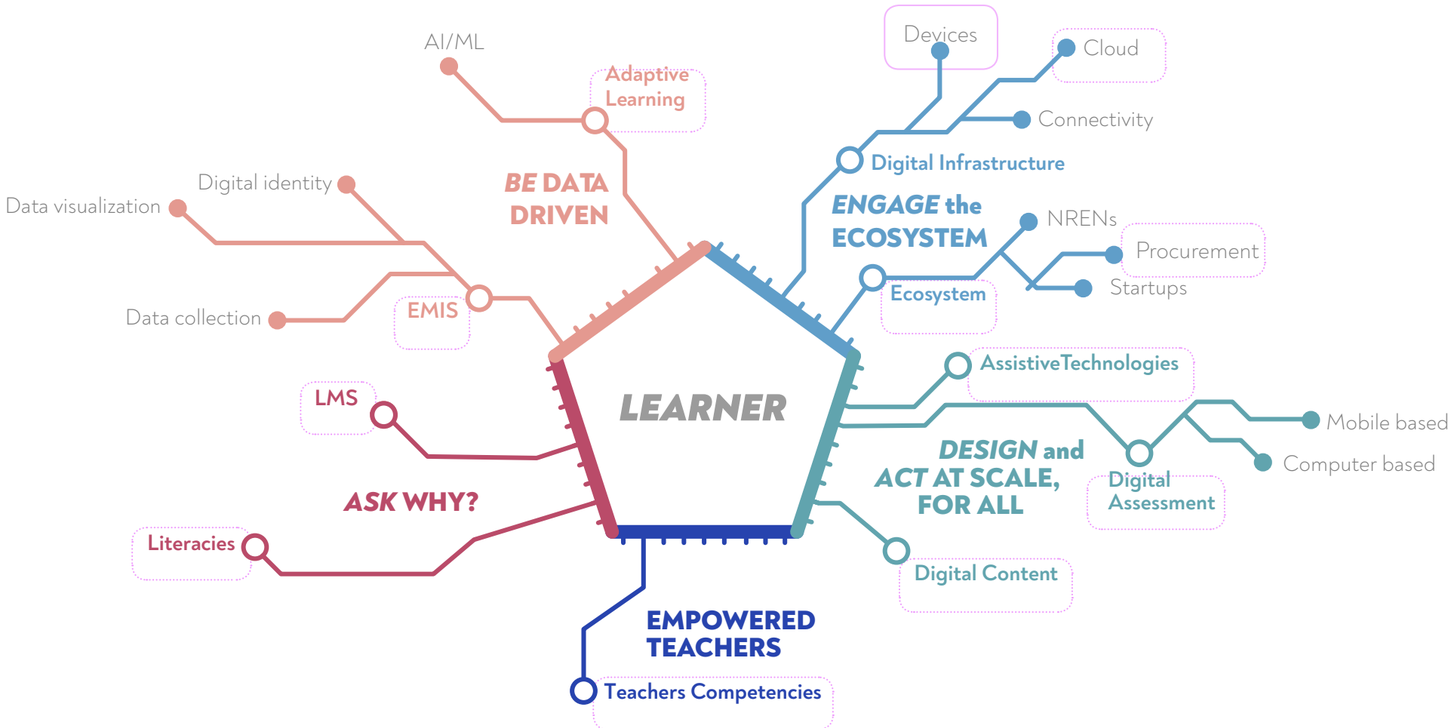
"Cloud" refers to a **Data Center connected to the internet in which IT resources** such as networks, servers, storage and applications **are delivered as services over the internet, on-demand and are scalable** (elastic). Cloud is a reality for an IT organization, so **it's a matter of "when cloud" not "if cloud"**.

HOW

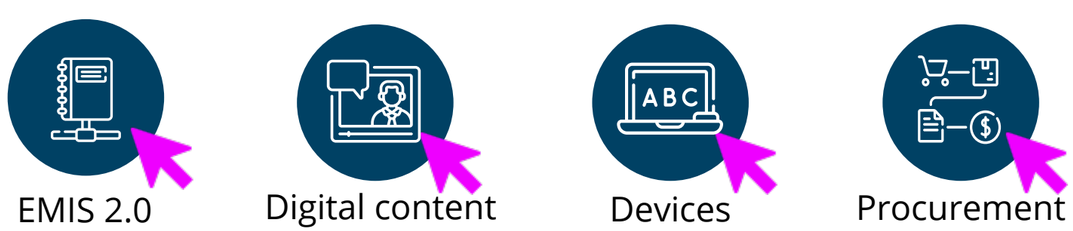
The **choice between a public, private or a hybrid cloud deployment depends on a variety of factors** and is rarely either/or situation in real world. It will be **essential to develop cloud literacy** within your organization so that you can make the right trade-offs between the variety of options. This Knowledge Pack is meant to introduce you to cloud and **help you create a cloud strategy or extend your existing cloud strategy.**

To go further

CLOUD OF KPs



OTHER EXISTING RELATED KPs



EMIS 2.0 | Digital content | Devices | Procurement

RELATED PODCASTS

Exploring the Potential of Digital Infrastructure in Education (on Apple Podcasts and Anchor)

Broadening Connectivity: A Conversation with Steve Song and Mike Jensen : Part I (on Apple Podcasts and Anchor) and Part II (on Apple Podcasts and Anchor)

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Annexes

KEY TERMS

On-Prem On Premises. This is IT infrastructure on your own premises, i.e. your datacenter.

Off-Prem Off Premises. This is IT infrastructure on somebody else's premises, i.e. their datacenter.

Public Cloud Cloud services provided by a Cloud Services Provider (e.g. Google, Amazon, Microsoft, etc.) and are available to other customers.

Private Cloud Cloud services (from hardware to the software) that is dedicated to you and not shared with anybody else. A private cloud could be on-prem or off-prem.

CSP Cloud Services Provider. CSPs can provide both public and private cloud services.

Hybrid Cloud This is a combination of both public cloud services and private cloud services.

AI & ML Artificial Intelligence and Machine Learning.

CSP Cloud services provider. CSPs provide both public and private cloud services.

M&E Monitoring and Evaluation.

Security Posture Or cybersecurity or threat posture (also security status) is the overall ability to defend against cyber-attacks. This posture includes policies, user training, and security HW and SW solutions in place, from anti-virus to face recognition for datacenter personnel to gain physical access to specific areas, etc.

Annexes

FAQ

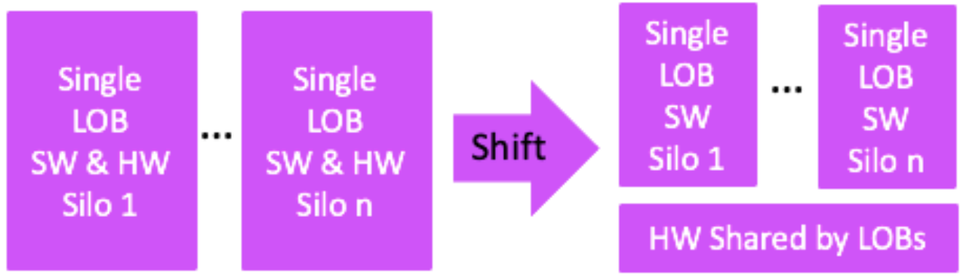
- How did Cloud come about?
- Where does Cloud fit in the IT timeline?
- Why are services at the core of Cloud?
- What are the different types of Cloud Services?
- What are Infrastructure Services?
- What are Platform Services?
- What are Software and Data Services?
- What is Virtualization?
- Is Cloud the same as off-prem?
- Is Private Cloud the same as off-prem?
- What do I need to know about Cloud Security and Privacy?
- What regulatory and privacy issues should I be aware of?
- How do you mitigate Connectivity issues?
- What is involved with a current state assessment?
- What are examples of VGOs and use case scenarios?

Annexes

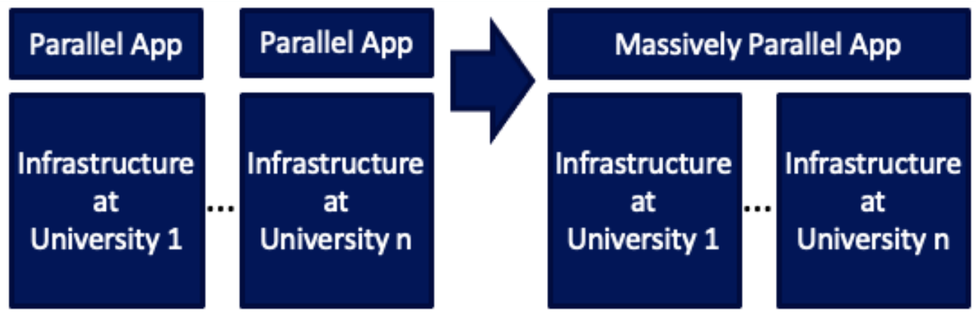
FAQ

How did Cloud come about?

a) Enterprise IT
Enterprise IT had been transitioning from LOB (line of business) SW & HW silos towards shared virtualized HW infrastructure



b) Research and Academia
Research and academia created pre-cloud standards for sharing infrastructure across multiple campuses.



c) SaaS Vendors
SaaS Vendors such as Amazon and Google, saw the infrastructure they were building as well as the IT services that they were providing for their own internal operations could be sold to external customers. This not only allowed them to be more efficient by selling their unused capacity, it also ended-up creating an enormous revenue stream on its own.

Back to FAQ

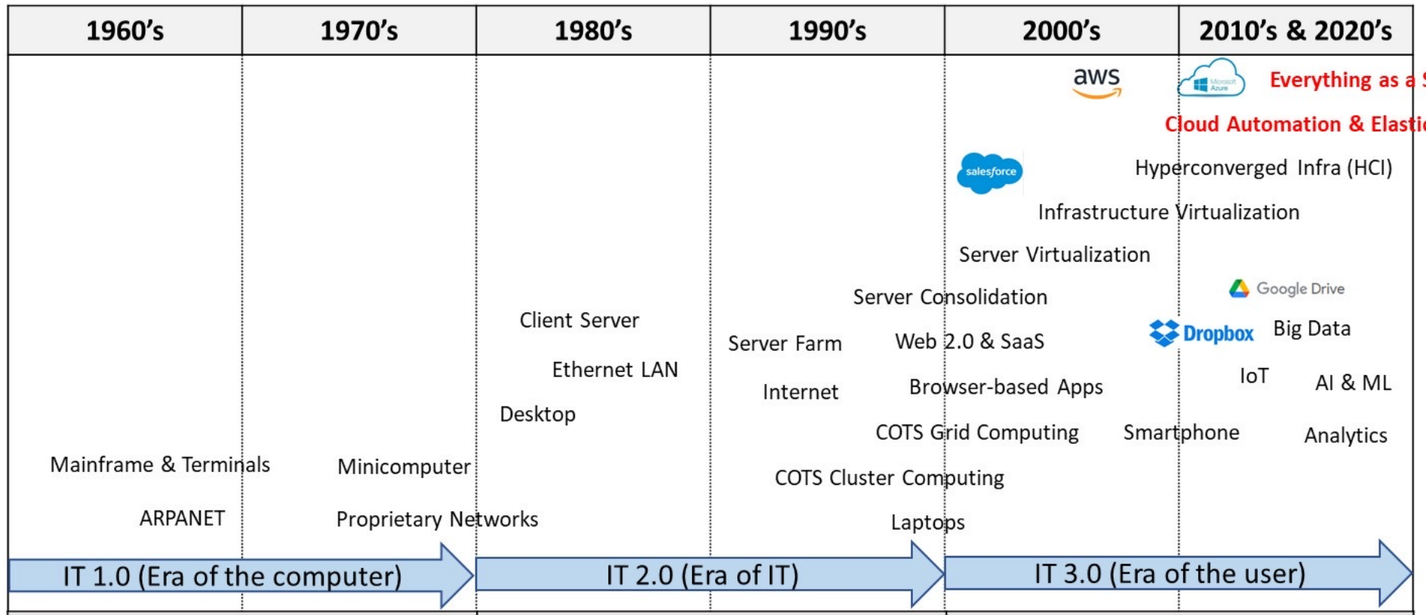
Cloud started as a convergence of
a) IT evolving in the enterprise,
b) research and academia sharing infrastructure to solve problems, and
c) SaaS vendors foreseeing an opportunity

Annexes

FAQ

Where does Cloud fit in the IT timeline?

Back to FAQ



	IT 1.0 (Era of the computer)	IT 2.0 (Era of IT)	IT 3.0 (Era of the user)
Design	Fixed, Rigid, and Purpose-Built. Single monolith.	Manual Provisioning. Multiple monolithic silos. Course-grain and difficult to scale up/down and/or out/in. Lots of hidden costs. TCO poorly understood.	Automatic Provisioning. Modular and reusable services. Fine-grain and easy to scale up and out. Costs optimized and managed.
Scale	1 computer to many users (mainframe)	1 computer to 1 user (PC and Internet)	Many computers to 1 user (ubiquitous)
Target User	For the elite (PhD's). Only large businesses and big science could afford.	Accessible to anybody (mostly Engineers, Scientists, Business, etc.). Used by most medium and large enterprises.	Utilized by everybody for everything (commerce, health, education, etc.). Used by consumers, and any-size business.
User Experience	It is what it is. Figure it out yourself.	Focus on enabling IT to respond to users' needs.	Focus on user experience and delivering user value. IT anticipates users' needs.

Annexes

FAQ

Why are services at the core of Cloud?

Back to FAQ

A Cloud service is simply some software capability or function accessed via an intranet or the Internet.

Services abstract their own implementation details, so that you don't have to know the details in order to use and benefit from a service.

EXAMPLE: "Sending Gmail"

Gmail is offered by Google, and when you click the Gmail "send" button, you don't have to worry about all the databases, servers, OS's, network routing, security, and much MOs more involved to make the service happen in delivering your email to somebody.

Cloud service abstraction ultimately allows you to focus on what you care most about, which is delivering education, NOT implementing technology.

Annexes

FAQ

Back to FAQ

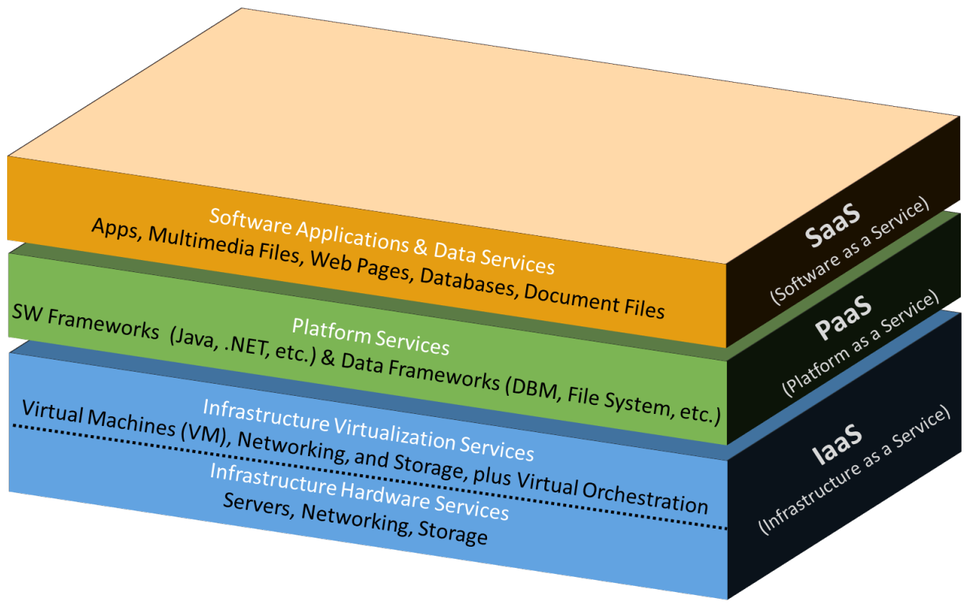
What are the different types of Cloud Services?

Cloud services combine and build on other services, so that sophisticated functionality can be created without requiring the expertise or detailed knowledge of the underlying services.

Infrastructure Services (or Infrastructure as a Service or IaaS) are the foundational services that provide the actual hardware the virtualization of that hardware, and the orchestration of the hardware's use.

Platform Services (or Platform as a Service or PaaS) are implemented on top of Infrastructure services, and provide the OS, as well as the SW and Data frameworks that are used to build applications, databases, etc.

Software and Data Services (or Software as a Service or SaaS) are built on top of PaaS, and are the actual applications and data that ultimately deliver end-user value.



Examples of Providers and Services

Microsoft Office 365, Google Apps, YouTube, Salesforce.com, Moodle, Dropbox, Facebook, etc.

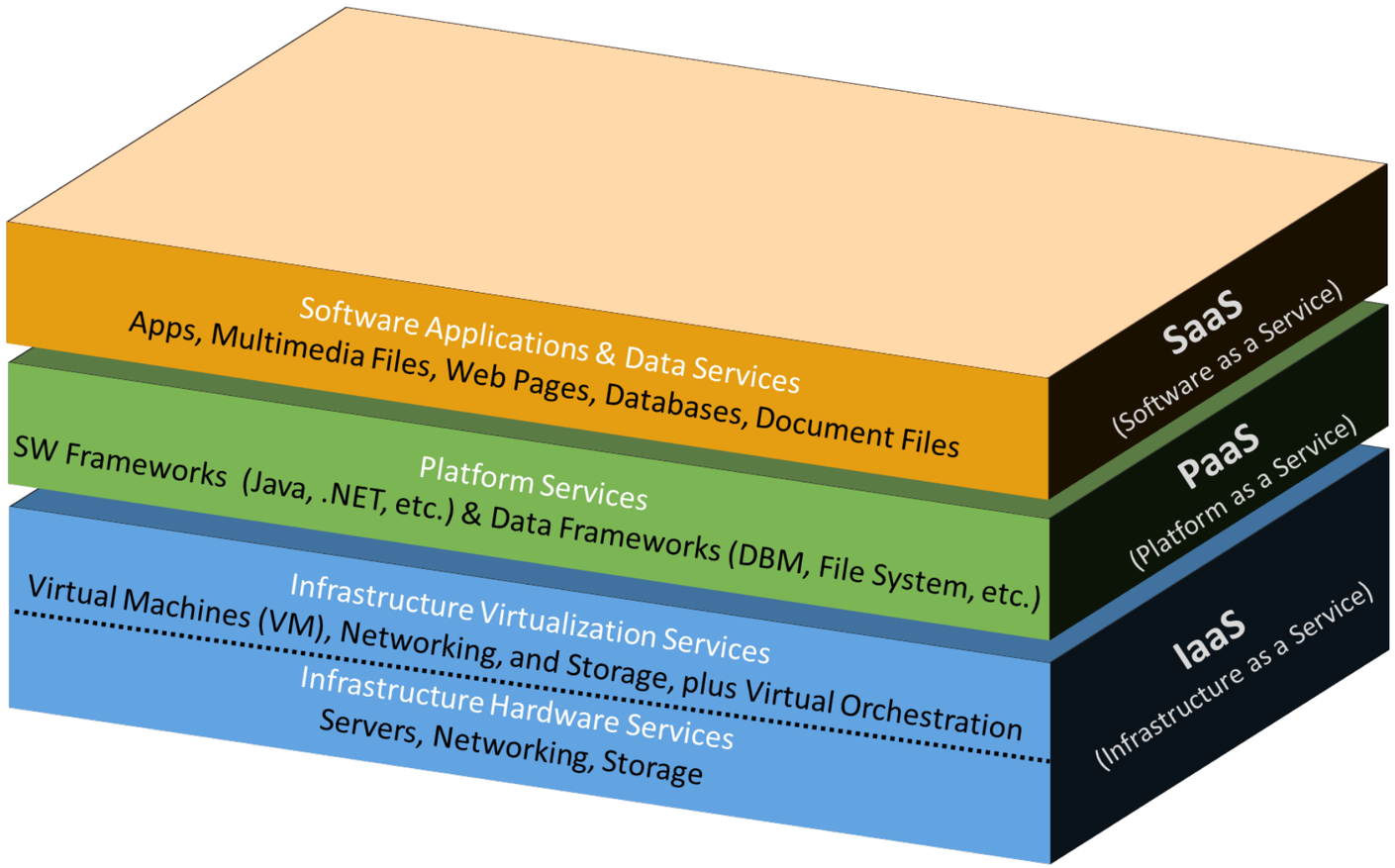
Microsoft Azure PaaS, Amazon PaaS, Google PaaS, Oracle PaaS, Linux, Windows, SQL Database, content delivery, workflow, etc.

Microsoft Azure IaaS, Amazon IaaS, VMware, Rackspace, VPN, Internet Gateway, etc.

Annexes

FAQ

What are Infrastructure Services?



Back to FAQ

IaaS is NOT just virtualization of server, storage, and networking hardware.

IaaS is often thought of as a virtual datacenter and includes:

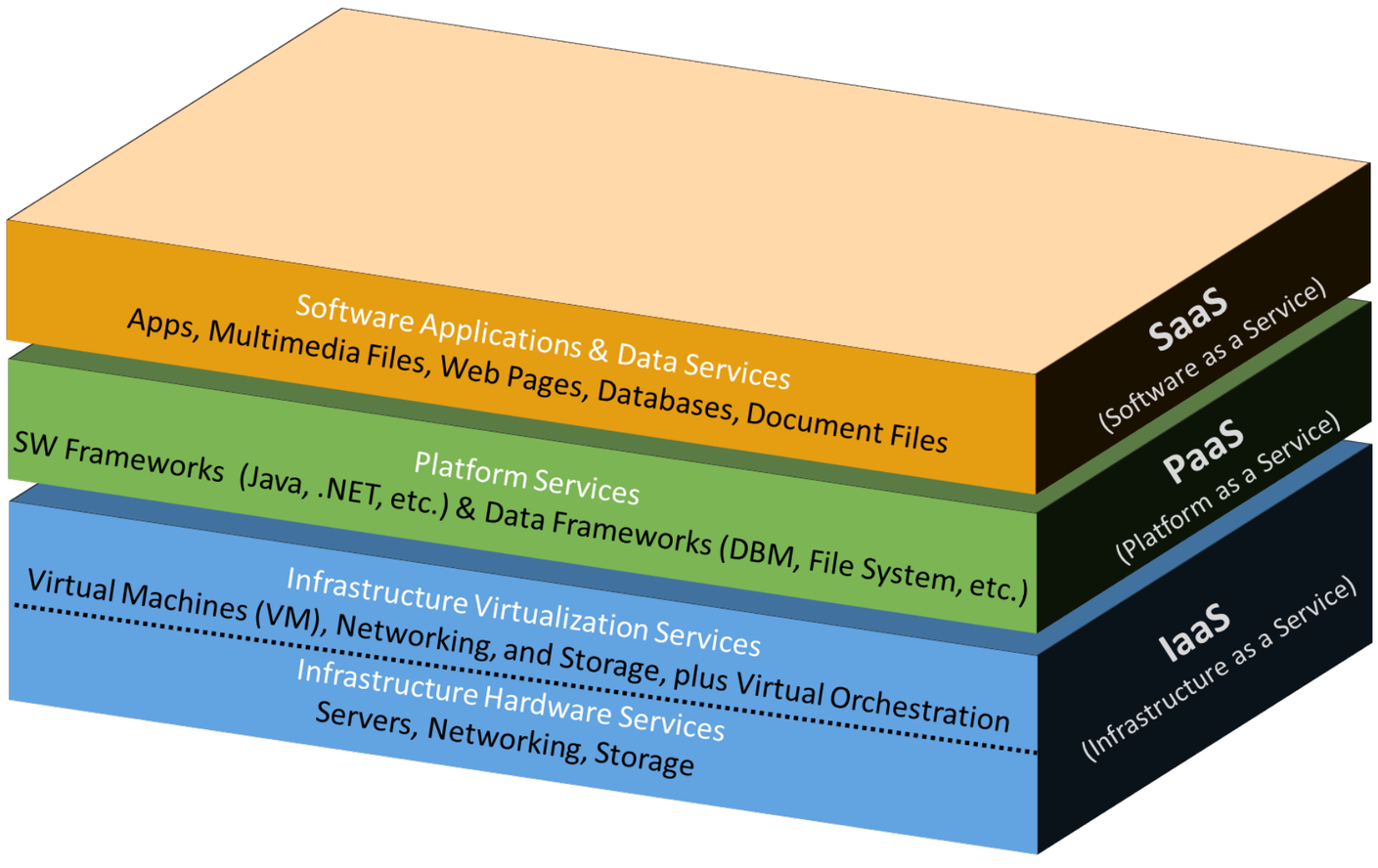
- Automated provisioning of virtual resources and the underlying hardware
- Dynamic scaling and sizing of virtualized resources
- Connectivity to the Internet
- Cybersecurity safeguards, firewalls, VPNs, and encryption
- Performance optimization of virtual servers, storage, and networking
- Physical building and personnel security

Annexes

FAQ

Back to FAQ

What are Platform Services?

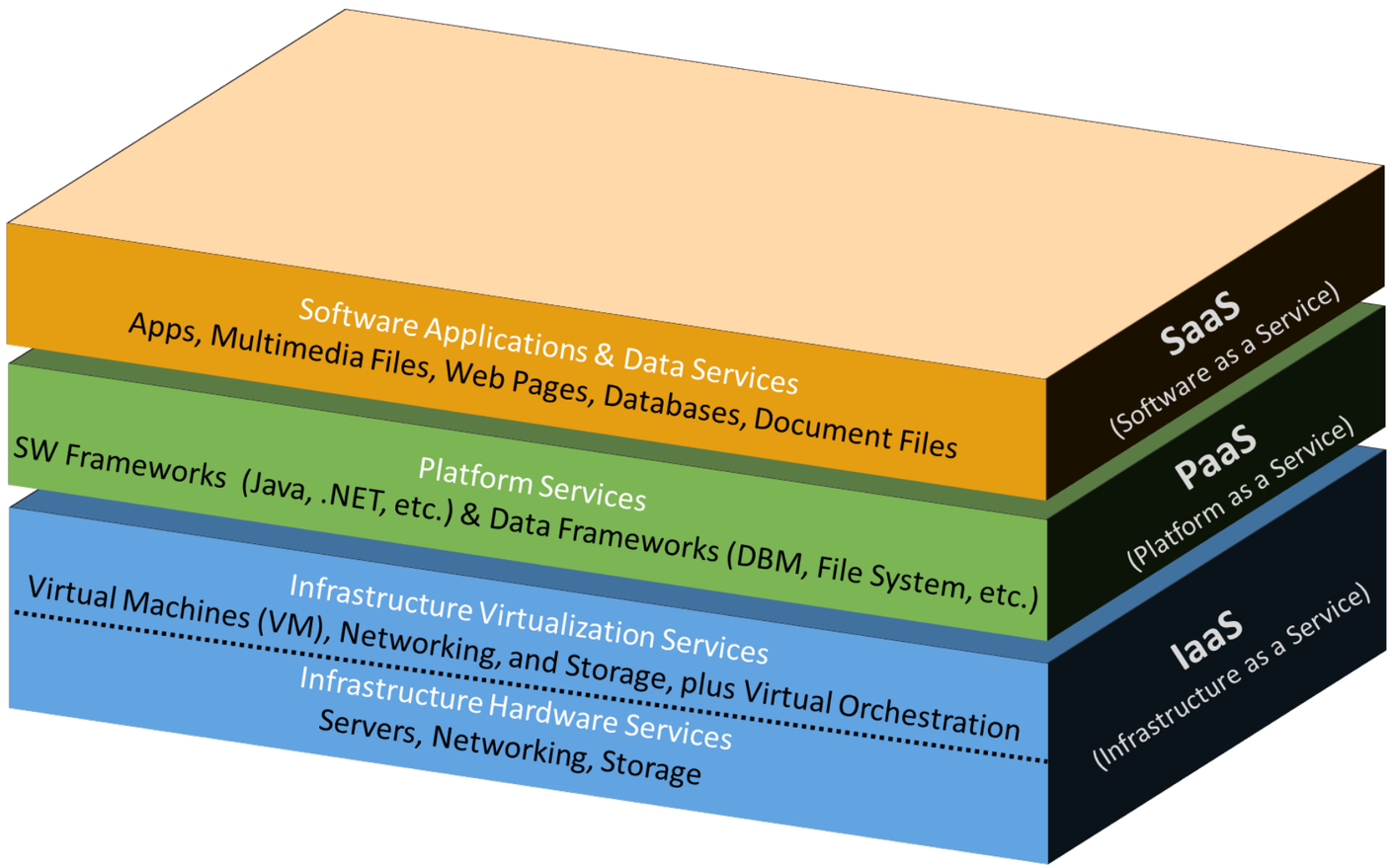


- IaaS runs on top of Platform Services, and PaaS itself is implemented on top of IaaS.
- PaaS is used to develop, manage, and run apps; as well as, develop, manage, and access data often in the form of databases.
- PaaS includes the OS's that run on VMs, and containers (OS virtualization).
- PaaS also includes analytics tools to gain insights from data, to monitor performance, to manage workflows, and many other capabilities.

Annexes

FAQ

What are Software and Data Services?



Back to FAQ

- SaaS is the actual applications and data that users access typically via the Internet, instead of having to download apps and maintain the data on their device.
- You typically think of SaaS as being 3rd party services such as Gmail, Outlook, Drop Box, Zoom, etc. or you can provide your own SaaS for your users.
- If you are procuring SaaS from a CSP, then you are not responsible for any of the other cloud layers.
- SaaS licensing and pricing is often managed as a per-user, monthly or yearly subscription.

Annexes

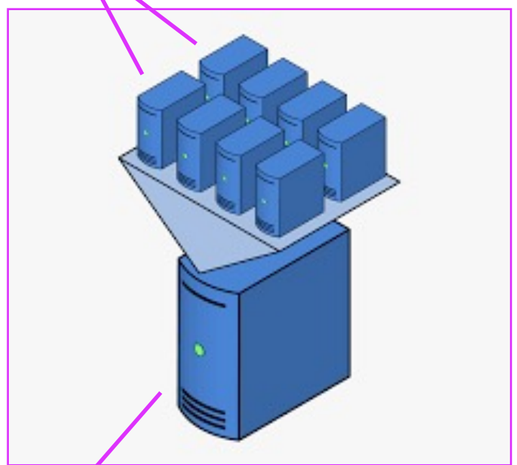
FAQ

What is Virtualization?

Back to FAQ

Virtualization creates a software representation of the physical servers, storage, and networking hardware, so that the PaaS and IaaS layers can be completely independent from the hardware.

Virtual machines (VM)



Physical Server

EXAMPLE: Server Virtualization

- Without server virtualization, you simply have a software running on top of dedicated physical server hardware.
- This is inherently inefficient since the server is not likely to be fully utilized and it's also difficult to move the software to a different server.
- Special virtualization software called a "hypervisor" creates standard multiple virtual servers (called virtual machines or VMs) running on top of the actual physical server.
- VMs can be added or removed to optimize utilization of the physical server, and completely different software can run on each VM.
- VMs can be moved around dynamically to different physical servers to accommodate more efficient network routing, performance, or security requirements.

Annexes

FAQ

Is Cloud the same as off-prem?

Back to FAQ

	On-Prem	Off-Prem
Private Cloud	You are responsible for everything from the IaaS layer (i.e. HW servers, storage, and networking) to the PaaS, SaaS, and EaaS layers. ANALOGY: This is like owning a car where you are responsible for everything, such as driving, parking, gas, cleaning, insurance, road tolls, cost of the car itself, driving, repair, maintenance, disposal, repurchase, etc.	A CSP (Cloud Service Provider) is responsible for providing (or hosting) the IaaS layer but it is dedicated only to you. You are typically responsible for the PaaS, SaaS, and EaaS layers on top of the IaaS layer. The CSP may provide IaaS layers to other customers but they are completely separate from each other. ANALOGY: This is like leasing a car in which you don't actually own the car but it's dedicated to you and you are responsible for insurance, gas and driving it.
Public Cloud	NOT A VALID OPTION	This is an on-demand public utility where the CSP (e.g. Google, AWS, and Azure) is responsible for the services (IaaS, PaaS, and/or SaaS) it provides and you only pay for what you use. ANALOGY: This is like using a taxi service in which you are not responsible for any aspect of the service other than just using the service.

Annexes

FAQ

Is Private Cloud the same as off-prem?

Back to FAQ

Private Cloud simply means that you are **NOT sharing** infrastructure services with other customers
EXAMPLE: the physical server that your software runs on is only used by you, the physical storage is only used by you, and the networks that communicate between those servers and storage are only used by you.

Private Cloud can be on-prem or off-prem
On-prem- In your own Data Center on your own premises with two options

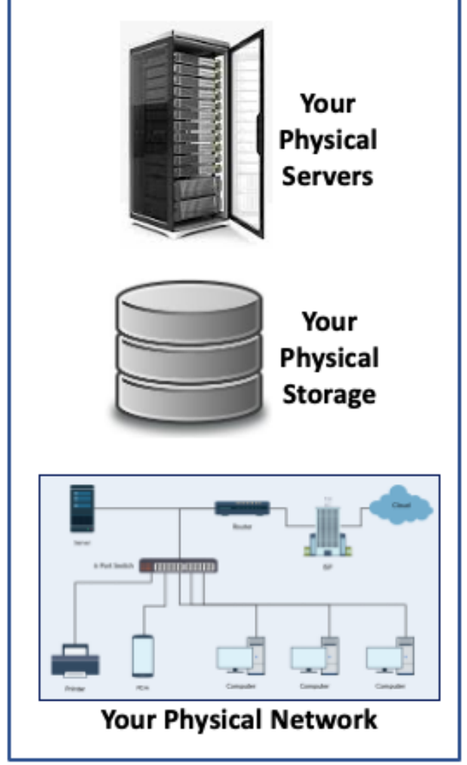
- Your own infrastructure- you own all the equipment and software
- Public Cloud Service Provider's infrastructure- most CSPs offer a limited version of their public offering infrastructure and/or software for installation in your own Data Center usually as part of a Hybrid Cloud Solution.

Off-prem- Rented space (and even servers) in someone else's Data Center

- Co-location- you rent space in someone else Data Center and you provide your own servers
- Virtual Private Cloud- Hosted by a Public Cloud Provider on their infrastructure not shared with anyone else

Public Cloud is always provided by a 3rd party CSP, so you are sharing infrastructure services with other customers.

EXAMPLE: one physical server may be running software from two different customers, but note that the software runs in its own environment, called a VM or virtual machine; and, a VM is virtually equivalent to having your own server.



Annexes

FAQ

What do I need to know about Cloud Security and Privacy?

Back to FAQ

Security and privacy are one of the top global IT concerns today

- **Security Technology and Controls:** Security and privacy is inherent with cloud and many CSPs have specialized technology and rigorous policies and controls to protect users' data and privacy as well as protect infrastructure and the cloud layers from threats.

- **Shared Responsibility:** Using a CSP implies a "shared responsibility" model in which, depending on the layer (IaaS, PaaS, or SaaS), CSPs are responsible for the layer(s) used and customers are responsible for securing the data they put in the cloud and setting access policies appropriately.

- **Data Encryption:** To secure your data, encryption is used to protect data both in transit (moving across the network) and at rest (while being stored).

- **Security Posture:** Your overall security objective is to have the best possible security posture, which is your overall ability to defend against cyber-attacks. This posture includes policies, user training, and security HW and SW solutions in place, from anti-virus to face recognition for datacenter personnel to gain physical access to specific areas, etc.

Note: Refer to "Journey to the Cloud: Improving Government Services through Cloud Solutions", section 2.1.2. on security.

Annexes

FAQ

What regulatory and privacy issues should I be aware of?

Back to FAQ

Data Sovereignty- the idea that data is subject to and governed by the laws of the country in which it is collected. Many country have enacted or are considering enacting Data Sovereignty laws.

Data Localization- laws that require that citizen's data be stored and processed on servers located in the country and in some cases that transfer of data outside the country follows some mandatory requirements.

The effect of these laws can mean that using the public cloud will require careful consideration as some cloud services rely on distributed servers across multiple countries to store and process data.

Cloud providers have developed several solutions to address Data Sovereignty and Data localization laws and it is recommended to engage Cloud providers to discuss what options are available.

One popular option is the use of Hybrid Cloud- with data stored on premise in the country some of the workloads running on the public cloud.

Annexes

FAQ

Back to FAQ

How do you mitigate Connectivity issues?

Is Cloud even possible with poor Internet connectivity?

CONNECTIVITY SCENARIO	MITIGATION
Internet costs are too high for my country	Use on-prem (or at least in-country) private cloud to deliver most cloud services, and then public cloud via Internet for very select services that make little or no sense to deliver via private cloud.
Low bandwidth Internet connectivity	• Use more full-featured devices that have sufficient storge for data. • School servers provide a hub for content that can be accessed by teacher and student devices. • School servers can be sideloaded, preloaded, or trickle loaded.

Annexes

FAQ

What is involved with a current state assessment?

- Conduct an inventory of all your current IT applications which could include your website, Student Information System, Education Management Information System (EMIS), Learning Management System (LMS), Teacher Management System, Financial Management Systems and others
- The inventory exercise should document number of users, vendors, integration touch points and security concerns
- Understand the behavior of your application- does it have steady usage, are there peak demand that are predictable or unpredictable. For example applications with unpredictable peaks are ideal for Cloud
- Review your backup policies and systems to ensure that all data is backed up prior to any Cloud deployments
- Consider your data sovereignty and security concerns if any
- Consider the connectivity situation of your key users
- Then look at your potential migration strategies

Back to FAQ

MIGRATION STRATEGIES

- **Rehost.** Move your existing application as is from your servers to an Infrastructure as a Service (IaaS) of a CSP or your own private cloud.
- **Replatform.** Move applications to the Cloud while tweaking them or using Cloud Databases and other platform tools.
- **Refactor.** Move applications to the Cloud while changing some of the code to make applications benefit from Cloud.
- **Repurchase.** A classic example is to move to a SaaS version of the same application you hosted inhouse.
- **Retire.** A chance to shut down applications that are no longer needed
- **Retain.** Applications that cannot be migrated for some reason.

Note: Refer to "Journey to the Cloud: Improving Government Services through Cloud Solutions", section 2.1.2. on security.

Annexes

FAQ

What are examples of VGOs and Use case scenarios?

Back to FAQ

GOAL	OBJECTIVES	USE CASES
Increase Access	• Enroll out of school youth • Ensure continuity of Learning/ Remote Learning • Build a flexible and resilient education system	• Teachers can i) create/ curate and deliver content ii) assess student learning iii) access professional development & support (coaching, mentoring) • Students can i) access learning content ii) seek support from teachers iii) communicate and collaborate with peers iv) participate in regular assessments • Administrators can i) track student enrollment, attendance & performance ii) communicate with students, teachers & parents
Improve learning	Lower learning poverty/ ensure children have foundation skills (literacy, numeracy)	• Teachers can i) have access to and use guided/ scripted lesson plans ii) determine the right level of students iii) conduct regular assessments iv) create additional learning aids/ content v) track student achievement vi) communicate with parents • Students can i) access additional practice & learning resources at school & at home ii) access support and instruction that is adapted and personalized to the child's level