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i-ERP Evolution and Data Center : *Myths and Realities*

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***Abstract*——From Over the past decade Data Center (DC) innovations such as convergence, hyper-convergence, Software Defined and cloud technologies available at a click of a button, as well as many application architecture modernization tools have changed data management. With the evolution of I-ERP, enterprises have scrambled to identify options best aligned with their business and technology needs. Business leaders have a responsibility to see through hype and identify the best solutions. They must also prepare their organization for risks/benefits of strategies they adopt. Leaders must ensure their investments in new technologies provide a competitive edge, improve agility position the enterprise for success. In outlining current data management trends evolving digital transformation, exploring the virtues and shortcomings of each, this paper highlights challenges, opportunities and some lessons learned. It provides IT and business executives a general guide on approaching the decision model of a DC migration, and factors to consider when contemplating a DC move while transforming classical ERP to I-ERP. DC move is a decision should be based on the future planning/strategies of any business moving towards Digital transformation or DC enablement to future technologies.**

***Keywords*---ERP, I-ERP, Digital transformation Traditional Data Center, Converged, Hyper-Converged Infrastructure, Software Defined, Cloud technologies, Private, Public, Hybrid, compute, storage, network, Containers, Orchestration.**

I. INTRODUCTION

Data is a valuable commodity for businesses in the new millennium and current age of digital transformation[1]. It has become critical to the success of multinational conglomerates with market valuations exceeding the GDP of many nations! Trillion-dollar companies like Google, Microsoft and Amazon rely heavily on data they collect from their users and other sources. They use the knowledge gained from mining that data to tailor their services and increase revenues. With compute, storage, and network technologies innovations, massive amounts of data are generated daily are stored, near effortlessly and at a steadily declining cost. Companies with ERP as their base systems moving to I-ERP to embed the digital future technologies into their business[2]. The first step towards moving from ERP to I-ERP is the database shift from Traditional or classic RDBMS database to new improvised cloud technologies and database which are more agile and forward looking[3]. For example- Any company having SAP as their main ERP system will now mandatorily need to move their DC shift from Oracle or any other RDBMS system to SAP S/4 HANA[4] which is bare minimum requirement for any enterprise having SAP to embed digital technologies like Block chain, IOT, AI etc.[5]. into their current business environments. Enterprises are now racing to collect, mine and benefit from data underscores the critical role of DCs for business success. DC innovations have increased the capabilities and lowered DC costs enabling them to handle the surging demand and changing requirements more efficiently.

II. TRADITIONAL DATA CENTER

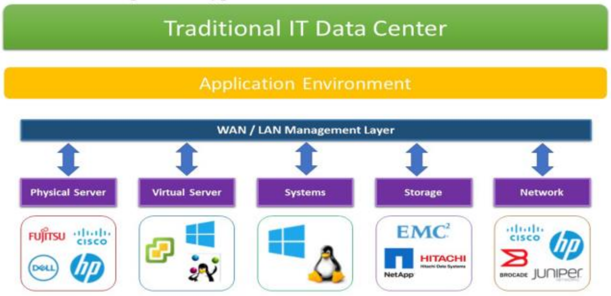
Enterprises with traditional ERP are on premises with separate physical HW to perform each major function, finite compute and storage to host apps and perform pre-defined data processing[6]. DCs were limited by physical space and power/HVAC systems.

Compute – In a traditional DC compute is limited by the number of physical servers/CPUs, rack/floor space, power and HVAC. Pre-virtualization, applications required dedicated servers leading to poor utilization. Virtualization improved efficiency but introduced new challenges and complexity.

Storage – Limited by the number of dedicated racks and disks. Storage array utilization was often lower than physical capacity with multitier disks required for many applications.

Network – Depended on performance of local provider. Dedicated backbone and gateways leave the burden of cost and maintenance on the enterprise with high CAPEX and the need for a large highly specialized IT organization.

Figure 1 - Typical Traditional IT Data Center



Facilities –ERP with On-Prem DCs require large CAPEX and annual OPEX for maintenance, upgrades, and hardware refresh, making DC expense a significant line item on the balance sheet. Limited, costly space and long lead times limited expansions. Role played by marketing intelligence will ensure to select correct DC for ERP. [7]

Myth: ERP with Traditional DC users are able to independently choose the most suitable suppliers for each function.
Reality: This put the burden of integration on the ERP, led to finger pointing by vendors, making strong enforceable support SLAs critical for vendors to take ownership. For most enterprises selections were limited to channel partner suppliers.

III. CONVERGED INFRASTRUCTURE (CI)

Enterprises Boosts compatibility and interoperability by bringing 4 core components (compute, storage, Network and virtualization) into a single interconnected, integrated rack with a centralized management platform.ERP with CI bundles a fully integrated, validated system to a single product, scalable to specified limits, with central management, support and maintenance[8].

CI building blocks – IT infrastructure (Compute, Storage, Network, hypervisor) is bundled in a single optimized solution with SW for system orchestration and centralized management:

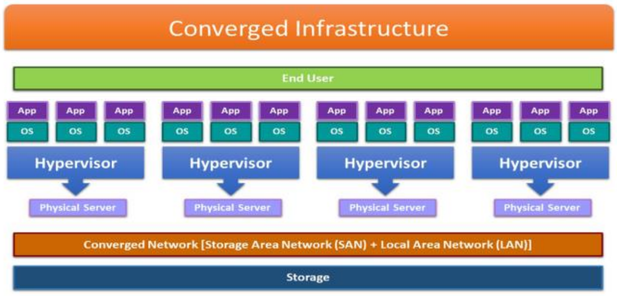
• Ongoing single vendor support and lifecycle management
• Consolidated systems for increased resource utilization ratio.
• Simplified deployment in blocks with automated operation.
• Private cloud service delivery, with predefined scalability.

CI components and configurations – Each component in the building block is discrete and could be used individually for its intended purpose. The server can be separated and used on its own, as can storage and network equipment.

•Components of the CI (compute/storage/network) are simple to understand if ordered in a predefined configuration.

•In CI storage is attached directly to the physical servers. Flash storage is generally used for high-performance applications and for caching from the attached disk-based storage.

Figure 2 - Typical Converged Infrastructure Topology



Category leaders:

•VCE VBLOCK: Cisco UCS/Nexus. VMware hypervisor ,Cisco Nexus, EMC Symmetrix VMAX or VNX Supports file and block SAN. VMW are, Cisco, EMC. Part of VMware
• Flexpod: Netapp, Cisco UCS/Nexus, VMware
• Hitachi UCP: Unified Compute Platform

Two primary ways to deploy CI

Reference architectures –Pre-validated configuration guidelines provide blueprints for type, quantity, and connectivity of converged system resources. This can leverage existing equipment to build trusted configurations. The resources are allocated and deployed per vendor recommendations. Individual components can be scaled up or out as required by application administrators.

Pre-racked configurations –ERP with CI have the compute, storage, and network components pre-installed in a datacenter rack. The components are often also pre-connected and cabled for rapid turn-up. This approach further accelerates deployments. But as the ratio of resources is predefined, if requirements change, scaling-out is the only way to change, as reconfiguration of existing systems is extremely difficult.

Myth: ERP systems with resources being shared in CI, run-away apps might starve other apps for resources.
Reality: With the proper monitoring tools app usage and resource utilization can be controlled and issues detected before becoming major problems. And with app baselining expectations are set accordingly.

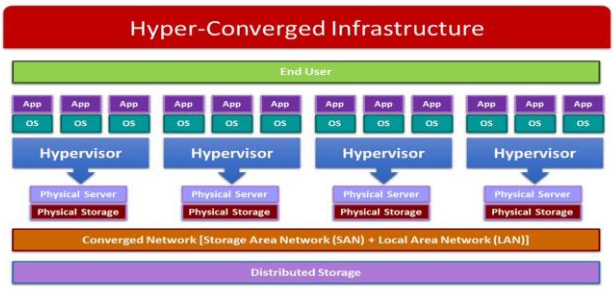
IV. HYPERCONVERGED INFRASTRUCTURE (HCI)

Hyper-convergence is a framework based on a hypervisor centric architecture[9]. It combines storage, compute, network and virtualization in a single box from a single supplier. ERP systems with this architecture reduces complexity, DC footprint and increases scalability. HCI platforms include a hypervisor for virtualized compute/networking, and software-defined storage. Solutions typically runs on standard off-the-shelf servers. Multiple nodes can be clustered together to create pools of shared compute and storage resources, designed for convenient consumption.

Focused on VM or workload, all elements of HCI support the VM as the basic construct of the DC[8]. HCI adds tighter integration between more components through SW with fixed resource ratios (CPU: Storage: Network). HCI solutions can be considered fully integrated, CI-like, IaaS-in-a-can, by a single vendor, for a "single throat to choke" support experience, avoiding the circle of blame of traditional IT.

HCI upgrades are simpler, because vendors have a narrower set of HW/SW combinations to worry about. This enables vendors to test the HW and SW stack more thoroughly. Accordingly, HCI vendors have refined customer support processes. HCI can integrate hardware management, storage, networking, hypervisor control, data protection, basic IT automation and orchestration all into a single interface.

Figure 3 - Typical Hyper-Converged Infrastructure Topology



• ERP is becoming intelligent and growing ecosystem of app suppliers are working with HCI vendors to certify apps on Smart SW on x86 based appliances. Enterprises can start small and expand as needed.

•HCI offers an appliance, with unified and integrated compute, storage, network & virtualization in a single scalable on-Prem infrastructure-as-a-service (IaaS) offering. This is suitable for ERP clients.

•To extend private cloud in to public cloud for ERP systems, almost all HCI vendors have forged technology and go-to-market partnerships with hyper scale public cloud providers. Again ERP will become smarter using this option

•Lower Capex, and Opex make HCI an attractive option. ERP customers utilizing Storage optimization techniques like deduplication and compression significantly improve performance when deploying capacity for general-purpose IaaS environments.

• Simplified operation to enable quick on boarding. Most HCI vendors embed their ops interface in a hypervisor, primarily the VMware stack. This helps lower OPEX and reduce personnel.

• Scalable infrastructure from a single provider with ongoing support/lifecycle management. HCI systems tend to be more reliable as the system scales out.

HCI technology is software defined, so in essence, all components are integrated and cannot be separated out. HCI has the storage controller function running as a service on each node in the cluster to improve scalability and resilience.

Myth: HCI is always the best solution for ERP S/4 HANA Greenfield implementation, and always the most cost-effective approach.
Reality: HCI does offer many benefits, but older monolithic app workloads may not use the environment most optimally. Different HCI offerings' performance and pricing should be matched with your requirements for the best results

Category Leaders:

- Nutanix, VMware, HPE, Cisco

V. SOFTWARE DEFINED DATA CENTER (SDDC)

A SDDC is a data storage facility in which all infrastructure elements (network/storage/CPU/security) are virtualized and delivered as a service[10]. Deployment, operation, provisioning and configuration are abstracted from HW and implemented through software intelligence. ERP systems with SDDC configurations are less vulnerable to risks.

Components of a SDDC

Virtualization is central to SDDC. There are three major SDDC building blocks:

• **Network virtualization –** Combines network resources by splitting available bandwidth to independent channels each assigned/reassigned to a particular server or device in real time.

•**Storage virtualization pools –** Physical storage from multiple network storage devices into what appears to be a single storage device managed from a central console.

• **Server virtualization –** Masks server resources, including the number and identity of physical servers, processors and operating systems, from server users. The intention is to spare users from managing complicated server-resource details. It also increases resource sharing and utilization, while maintaining the ability to expand capacity later.

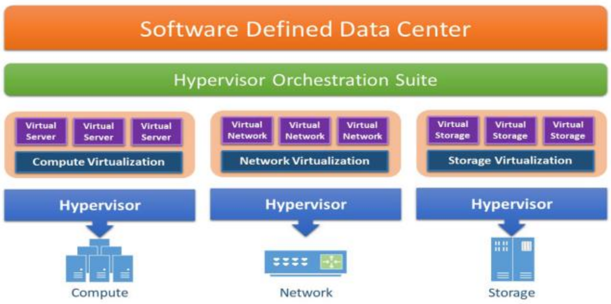
SDDC benefits and challenges

Though HCI and SDDC shares many characteristics, the policy driven monitoring, automation, provisioning, capacity planning and management in the orchestration layer is what gives SDDC the edge. SDDC allows the DC to be managed as unified system within ERP or an aggregate set of domains making it a private cloud. In the SDDC, separation of control and data planes, the agility, elasticity and scalability of cloud computing all provide enterprises the ability to provision, and configure application, infrastructure and IT resources seamlessly. Automation capability replaces cumbersome traditionally manual, labor intensive, error prone provisioning and operational management and reduces cost and overhead. This SW centric approach requires revamping of integrated IT security to adapt policies to counter threats (policies based on application, content, users and role-based access level). With SDDC, cloud applications becomes core in ERP and make it more intelligent[10].

Power savings – With energy efficient x86-64 processors at the core of the SDDC platform, hardware offload benefits are important metrics to consider when evaluating solution alternatives, and power and cooling savings they offer.

Reduced management complexity – SDN and automation help reduce management/operational complexities and costs by utilizing Open Virtual Network (OVN) SDN solutions such as VXLAN or NVGRE compared to traditional DCs.

Figure 4 - Typical Software Defined Data Center



SW stability – Vendor supported SW and application stack trades the dependence on custom built solutions for the free open source SW stack to manage their infrastructure.

Integrated management and monitoring – Smart deployment with integrated diagnostics of virtual, and physical components provides focus on monitoring trouble spots and enhanced troubleshooting. Monitoring tools connected to key components reduce issue diagnosis/resolution time with added ability to analyze the data in a Big Data solution. The transition from Traditional DC to a cloud centric SDDC comes with benefits and challenges. It improves accessibility, flexibility, scalability and cost efficiency.

VI. CLOUD DATA SERVICES

With I-ERP getting popular, data services also going as Cloud services which enable access to IT Services from a public cloud provider or from the Enterprise hosted Private cloud. The on-demand access to a highly reliable global network of infrastructure, at significant savings (if planned properly, with controls in place) provide a level of versatility and flexibility that lead to exponential growth in cloud service adoption.

The attraction to Cloud Stems from the ease and speed of remote access to a large variety of resources, the flexibility to size them to current demand and Scale them as demand changes. Remote access via the internet has conveniences but also has challenges (e.g. security). With the cloud physical infrastructure owned and managed by the providers, it relieves the enterprise from the complexities and costs of ownership and operation. Pay as you go, tiered performance-based pricing and provision on demand are convenient options for users.

Deploy ability – Fast delivery of services from standard, preconfigured, scalable, and measurable units by Cloud vendors based on common economies of scale.

Flexibility – As requirements change, users can switch between available services, and pay as they go. This is made possible by the cloud provider's ability to redirect resources[11].

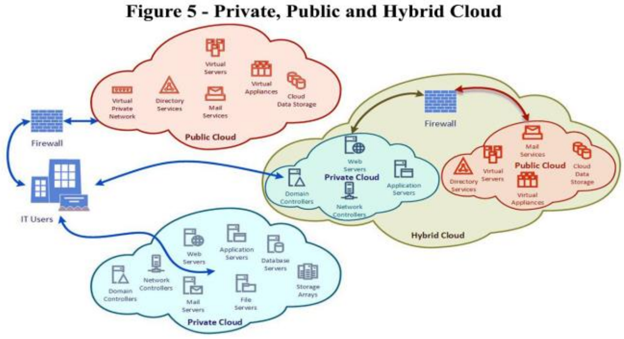
Utility –With proper planning and controls, high resource utilization, low per unit cost and high availability are all attainable in the shared model of public cloud.

Cloud Models

Public Cloud –Another ERP deploy option is Public Cloud. Public IT services offered by providers who own and manage the infrastructure and services. Public cloud offers robust service catalogues, highest availability and access to globally distributed locations[12]. Normally enterprises incur no up-front CAPEX and low OPEX for services. Enterprises do lose most control over their environment which increases the potential risk of exposure of sensitive data and IP. Mitigation requires monitoring of the supplier's security practices, and standards compliance. Carefully managing the procurement of resources, their utilizations and placing proper controls can lead to significant cost savings. Enterprises personnel can focus on strategic work and leave tactical tasks to the cloud provider.

Private Cloud –ERP Enterprise offered IT Services utilizing CI, HCI, SDDC and Orchestration Layer form a cloud service offering for internal users. Private cloud offers enterprises full control and ownership of IT infrastructure, reduced CAPEX and OPEX are achievable with careful planning/management. With this model the enterprises still responsible for maintaining large highly specialized IT Teams.

Figure 5 - Private, Public and Hybrid Cloud



Hybrid Cloud – The IT environments formed by selecting private and public cloud services based on requirements, capabilities, strengths and cost to operate each[13]. This model may add challenges in seamless environment integration (e.g. APIs), possible multiple orchestration layer and higher CAPEX.

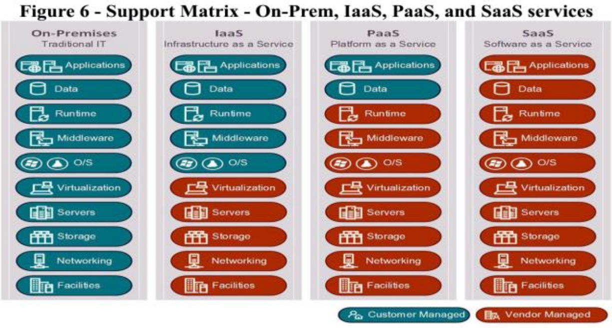
Cloud Service Classifications

IaaS (Infrastructure as a Service) – Virtual access to compute, storage, networking, and security services from Private or Public Cloud[14]. The users are responsible for operating system, application, database configuration and management on top of virtual infrastructure. Enterprises enjoy the flexibility and scalability without owning the physical infrastructure.

PaaS (Platform as a Service) – provides a virtual environment Such as Database, with the OS and supporting run time utilities[15]. The client installs their application, loads their data and utilizes the platform. The client is fully responsible for their application and data while the provider controls and manages the underlying platform. Cloud providers own the responsibility of managing infrastructure from the OS and below relieving the enterprises from managing them. Heroku, Sales force, and Google App Engine are examples of PaaS[16].

SaaS (Software as a Service) – SaaS provides preconfigured, standardized ready to use SW packages to the users. The services are typically accessed via desktop client or web browsers with no requirement to store any data locally[17]. While access and output management are user responsibility, everything from Software and below is owned and managed by the cloud provider. Examples: Office365, Apple iCloud, Drop Box, Mail Chimp, and Netflix[18].

Figure 6 - Support Matrix - On-Prem, IaaS, PaaS, and SaaS services



Key success factors for cloud adoption

Understand the business case for cloud – Define and understand the cloud migration business case and benefits before deciding. Knowing why a business needs another place to store data or deploy applications make cloud adoption easier[19].

Plan cloud adoption in phases – Cloud migration is complex and may take years to complete[20]. Classifying applications and data and prioritizing non-essentials to move first, proves the concept before migrating sensitive data.

Identify/correct cloud adoption problems – Early analysis, anticipation of possible issues during migration (compatibility performance issues) and planning to work around or resolve the issues is important for a successful migration.

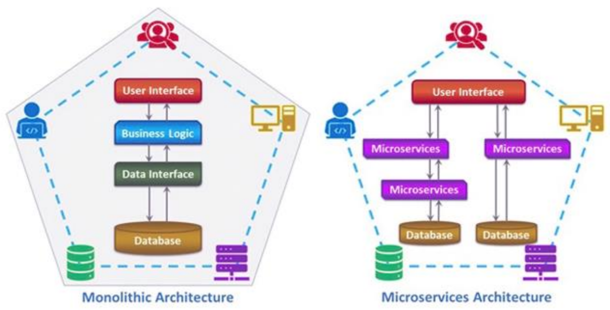
Evaluate full cloud migration experience – A cloud adoption strategy includes monitoring and noting lessons learned from all stages of the transformation, starting with introduction, through the migration stages, to operation in the cloud[21]. This helps assess how it went, what went wrong, how it was corrected, and if another course of action is required. SW Integrators can customize a migration strategy to assist an enterprise with their migration and ensure a success[22].

> **Myth:** Once ERP have moved to the cloud, it is done.
> **Reality:** Post migration, periodic reviews of strategy and ongoing cost and performance management are key.

Review/adapt cloud strategy, manage –
What was successfully completed? How long will remaining steps take? How do cloud performance/cost metrics compare? What refactoring/rewrites are needed to take full advantage of cloud? A cloud implementation plan shall include post-migration activities for cloud adoption success

Modernize Application services – Application Service decoupled into micro services utilizing containers and orchestration are a key factor for successful cloud deployment[14].

Figure 7 - Monolithic and Microservices Architectures



•Application Architecture – Monolithic application architecture presents issues like maintaining a huge codebase, new technology adoption, scalability, change management[23]. Strategizing on service decoupling and when and how to migrate are important to the monolithic to cloud transition.

•Containerization – Containerization is a process to package application along with its required libraries, frameworks and configuration files to make it platform independent[24]. Containerization enables applications to utilize hardware resources with optimal performance and no dependency on a hypervisor layer giving it an edge over virtualization in terms of isolation and portability.

•Orchestration – Organizes multiple services to usable coordinated results and automates end-to-end tasks in sequence from request to delivery[25]. Well-tuned orchestration is key for a successful, cost-effective and efficient cloud environment.

VII. SUMMARY

ERP systems with traditional DCs, channel partners/Systems Integrators helped integrate/support multiple HW/SW products. The enterprise sourced compute, storage, network hypervisor, OS and in some cases even applications from a single SI and receive support for it as one system. In some cases, the SIs would even write custom SW to integrate various components.

Table 1 - Basic comparison of Traditional, Converged, Hyper-converged, SDDC and Cloud

	Traditional DC	Converged Infra (CI)	Hyperconverged (HCI)	SDDC	Cloud
Infrastructure	HW Centric	Hybrid	SW Centric	SW Centric	SW/web Centric
Architecture	Distributed Separate HW	Discreet HW components in an integrated system.	Centralized HW Management with Integrated HW	Portal based application component management	Highly scalable, highly flexible; highly efficient and on-demand
Cost	CapEx intensive, higher CapEx and OpEx costs	Generic IaaS lower OpEx	Lower CapEx and OpEx	Standard HW/SW Lower CapEx/OpEx	OpEx intensive, smallest IT, least specialized and Service based OpEx
Provisioning	Long lead-time, high expense for change	Vendor builds, sells, and supports as a single SKU	Higher scalability, flexibility, efficiency	Highly scalable, Highly flexible, highly efficient, lower lead time	Short lead-times, lowest cost for change, not ideal for sensitive data (public)
Procurement	Largest vender selection	Limited vendor selection Limited config changes	Limited vendor selection. Coordinated config changes	Standard vendor selection, catalog based config model	Limited Vendor Selection Least control (public)
Support	Large Highly Specialized internal IT	Moderate sized IT	Smaller IT	Smaller IT	Smallest, least specialized IT
Operations	Separate Component management/monitoring	Central management below hypervisor	Central management per unit (for basic), Central management at DC level available for additional cost	Central management/monitoring full DC	Central management across data centers

CI brings lower layers up to the hypervisor to one block of physically separate logically integrated HW/SW, preconfigured components to specific size limits, supported by one provider.

HCI integrates same components in one chassis with standard HW, onboard unified control/management/provision system.

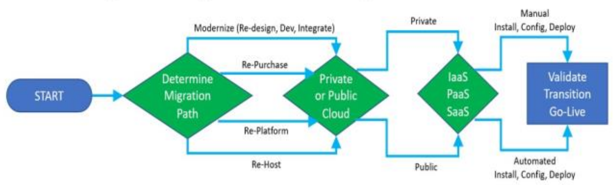
SDDC integrates components such as LBs and firewalls in to SW based and elevates the centralized integration/control

to cover more of the DC. SDDC adds an orchestration layer with policy driven automation and management and enables more efficient demand-based resource configuration.
Cloud enables integration, central management tools similar to SDDC. Private cloud extends integration/control to multiple Enterprise DCs. Public cloud extends that globally, eliminating the headaches of physical infrastructure ownership.
Common Theme: limiting/standardizing the number of accessible options simplifies deployment/management and support and maintenance.

Myth: Multi-cloud prevents lock-in within ERP.
Reality: Several factors contribute to cloud lock-in. avoiding multiyear commitments and avoiding proprietary services are key to maintain cloud neutrality and avoid lock-in.

None of the options listed are perfect solutions, none fit all I-ERP deployment scenarios[15].Each has strengths and weaknesses, and deployment scenarios they are best suited for[26]. Example: Public cloud adds flexibility, agility/speed over HCI and SDDC, but compromise ownership, control, security and possibly pricing. The table above highlights the main similarities/differences.

Figure 8 - High Level Cloud Adoption Decision Tree



VIII. CONCLUSION

IT leaders considering a new DC strategy to migrate from Classic ERP to I-ERP and should utilize enterprise architecture methodologies like TOGAF/Zachman as they fit the organization needs to verify and document requirements, capabilities, and limitations and identify/implement the best solutions[27]. Begin with understanding the organization vision, business architecture and objectives. Identify technical needs, compare against current state and team core competencies, existing HW/SW/OS, and licenses and where they are in their lifecycles. Evaluate existing application's architecture to narrow target environments, establish awareness and set expectations for apps that may require modernization to effectively host in new environments. Modernization feasibility studies help determine the best options. Depending on internal competencies, some steps may require external expertise to complete.
Finally, as results of these efforts, the enterprise identifies environments, technologies and deployments best aligned with company strategy. A hybrid solution might best meet varying requirements of the business and net the best results.

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