Document name	Code	Segment	Created by
Ahmad2020-Cloud_Computing_Trends_and_Cloud_Migration_Tuple	CLOUD SERVICE PROVIDERS > Cloud provider	In order of highest revenue share, these services are cloud application services (SaaS), cloud business process services (BPaaS), cloud system infrastructure services (IaaS), cloud application infrastructure services (PaaS), and cloud management and security services. And top 5 leading pubic cloud service providers along with their cloud services are Microsoft (SaaS, IaaS, and PaaS), Amazon (IaaS and PaaS), IBM (SaaS, IaaS, and PaaS), Salesforce (SaaS and PaaS), and SAP (SaaS, IaaS, and PaaS) [4], whereas cloud management and security services are the integral offerings of all cloud vendors. Leading traditional business process outsourcing (BPO)	Ivon Miranda Santos
Ahmad2020-Cloud_Computing_Trends_and_Cloud_Migration_Tuple	CLOUD SERVICE PROVIDERS > Cloud provider	There is another virtualization technology, containers. Many large cloud providers such Google, Joyent, IBM/Softlayer, and others offer them [13]. Mostly containers utilize Linux kernel containment features, LXC.Containers sharingthe same host OS, therefore, are lighter and hundreds of them can be run on single hardware machine, whereas on top of hypervisors, each VM can have	Ivon Miranda Santos
Ahmad2020-Cloud_Computing_Trends_and_Cloud_Migration_Tuple	CLOUD SERVICE PROVIDERS > Cloud provider	Mobile: Support for mobile computing is a mandatory condition for all the lead-ing cloud service providers. Mobile edge computing is also essential to solve the problems of jitter and	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	ABSTRACT Cloud computing has become a widely exploited research area in academia and industry. Cloud computing benefits both cloud services providers (CSPs) and consumers. The security challenges associated with cloud	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	Studies [8] and [10]–[11] emphasized general cloud secu-rity models such as SaaS, PaaS, IaaS, and CaaS. Empirical studies show that these models play an important role in cloud security from the perspectives of cloud security providers and clients. However, a successive range of cloud security models is more important to safeguard	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	It has become essential to counteract the occurred and potential attacks [14]. Presence of the insecure interfaces is a big challenge to both cloud users and cloud service providers. Cloud services' security and availability mainly depend on APIs that involve in data access and data encryption on clouds.	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	C. INTRUSION DETECTION SYSTEM Cloud service manager as a cloud provider must follow the service level agreements (SLAs) and conform to technical standards. Cloud data on cloud premises needs to be protected from physical and crypto-graphical intrusion attacks [20].	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	4) AUDITING AND UNIT TESTING Cloud providers should have control over the auditing and maintenance of cloud services. It can be achieved through the	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud testing is a hope to determine the balance of advantages and risks of cloud computing services. Cloud service providers and customers perform cloud testing at their levels. On the other hand, the customer is responsible for per-forming tests to avoid or mitigate any risk to its organization or customers.	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	Still, there is no way of using the outcomes of third party checking for external users. To make users more trusting in an organization's cloud services, we need to get their feedback for further quality evaluation of cloud providers' services. 5) CLOUD RESOURCES MANAGEMENT	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud computing services models concern the management of cloud resources. Cloud service providers offer clients resources such as virtual machines, network devices, load balancers, and firewalls. Resource management is one of the pressing issues of IaaS [30]. Services availability directly links to the security of physical equipment and devices at premises of cloud service providers. Denial of service attack makes resources unavailable for the intended consumers	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	3, tenants may keep their own host-based security tools (HBST) to run on their virtual machines. They obtain virtual machines from cloud providers. Thus, monitor-ing a system through the HBST has	Ivon Miranda Santos

Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	2) RQ2: What are the security problems that have not been addressed by commercial cloud providers?	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	In table 3, it has become clear that cloud computing and its security concerns have remained the focus of researchers in the last few years. Second, the chosen studies research focus shows that cloud computing has advantages for both cloud service providers and users. However, cloud consumers' concerns about infor-mation security have made them rethink before they use	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud services users do not need to become unauthorized users of services, but internal individuals of CSP organization present malicious behavior. In studies [20] and [37], we have found such incidents, which can harm the data security from cloud service providers. Therefore, trust-building between client and cloud service providers is emphasized through a unity model. The emerging paradigm of cloud computing ensures the reliability, availability, and scalability	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	The key-splitting and Homo-morphic encryption can be extended to have new breakthroughs in this area of research [38]. In [39], the emphasis was on secure data transfer between customers and cloud computing providers over the secured communication channels. A group of researchers proposed an attack model in [40], where they identified the three most	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	They fear any unauthorized users can access the information as cloud computing simply lingers in cyberspace. Respective cloud computing providers ensure security and privacy in cloud computing [41]. If the infrastructure of cloud computing is insecure, the information's availability and confidentiality become at risk.	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	This approach accomplishes the use of keys in two ways. Cloud service providers never retain the keys, instead their clients retain keys locally and ensure that used keys are destroyed or rotated correctly. Microsoft and Amazon have made advancements in making the simple storage service (S3) available for customers through	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	5 shows us the seven identified types of cloud com-puting security concerns in research studies. Data tampering and leakage are the deepest valued concerns for both clients and cloud computing service providers. These types of cloud computing security issues encompass cloud computing users who cannot access cloud computing resources.	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	In [41], data con-fidentiality and availability have been called primary secu-rity concerns irrespective of other security lapses between clients and cloud computing services. A secure communica-tion between clients and cloud computing service providers is the second-highest score regarding cloud computing security risks. We have pointed out the IaaS level concerns as a separate type of	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	As a result, security issues emerge in the confidentiality of stored data during outsourcing of data to a user. B. COMMERCIAL CLOUD COMPUTING PROVIDERS AND SECURITY CHALLENGES (RQ2) A survey study [53] finds that the top five cloud providers, including Amazon, Azure, Adobe, Google cloud platform, and VMWare, are efficient in their cloud services' data secu-rity feature. Reliability and performance are among other features. To measure the cloud providers' trustworthiness is still an issue for researchers, and a customer cannot judge it without appropriate tools. Container launched by VMs is an emerging practice offering security sandboxing. Containers enable the cloud providers to continue managing their appli-cations on clouds [54]. Since application management at the edge is challenging for cloud providers, it is done either ad hoc or with the platform. When multi-tenant run their appli-cations on the same host resource, security, and privacy issues arise from their applications. Existing literature on com-mercial	Ivon Miranda Santos

Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	requirements at the right time [13]. National laws also conflict with the SLAs that enforce the cloud computing service providers to disclose their customers' sensitive information [61]. Cloud computing pro-cesses and elements like APIs did not follow the cloud com-puting standards that presented a barrier for clients to switch cloud suppliers without expense and pain	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	In addition to these advantages, cloud client did not require the initial capital to invest in the infrastructure. Cloud clients shift their risks to cloud computing service providers. Literature reveals that cloud computing and social media have become an influencing factor in controlling and mon-itoring public policies.	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	It leads to an ambiguity in the minds of users. Thus, the cloud provider must ensure users' information by installing data safety measures. Although CC has many deployment and implementation benefits, organizations adopting them face compliance, trust, hosting, legal,	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	challenges. This paper provides a substantial growing liter-ature on cloud computing security challenges, commercial cloud services providers, cloud consumers' concerns, and blockchain technology. The proposed taxonomy, as shown in	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	6). It is crucial to introspect the cur-rent approaches on cloud security, cloud security addressed by commercial cloud computing services providers, and blockchain technology. Security threats have been studied in the literature than consumers' concern (42% vs. 17%), while security techniques with blockchain technology are	Ivon Miranda Santos
Alouffi2021-A_systematic_literature_review_on_cloud_computing_s	CLOUD SERVICE PROVIDERS > Cloud provider	This SLR identified commercial cloud services providers and highlighted the security issues they face during cloud services deployment and implementation. The trustworthiness of cloud users is challenging to con-sumers of commercial cloud services providers. Data unavail-ability, insufficient security measures, and vendor lock-in,	Ivon Miranda Santos
Ardagna2015-Cloud_and_multi-cloud_computing_Current_challenges_	CLOUD SERVICE PROVIDERS > Cloud provider	Also networks are frequently the Cloud bottleneck and data center energy management is very critical [7]. To cope with such challenges the adoption of multi-Clouds [8], has been advocated by many researchers, since deploying software on multiple Clouds overcomes single provider un-availability and allows to build cost efficient follow the sun applications. Moreover, Cloud computing is also becoming a mainstream solution to provide very large clusters in a pay per use basis to support Big data applications [9]. Many cloud providers already include in their offering MapReduce based platforms (i.e., one of the most adopted framework to support large volume unstructured	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	Migrating applications to the cloud is rapidly increasing in many orga-nizations as it enables them to take advantages of the cloud, such as the lower costs and accessibility of data. Moreover, such organizations typically try to avoid sticking to a single cloud provider and rather prefer to be able to spread out their applications across different providers. However, there are many challenges in	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The use of cloud computing is increasing rapidly in many organizations [1]. Moving an application to the cloud enables organization to make use of the advantages of the cloud like elasticity [2], lower costs, and accessibility of data. To further utilize these advantages, achieve maximum flexibility, and avoid "concentration risk" (putting too many application eggs in one cloud basket), organizations recently tend to spread their applications across different cloud provider. According to a recent study [3], 85% of © Springer Nature Switzerland AG 2021 H. Hacid et al. (Eds.): ICSOC 2020 Workshops, LNCS 12632, pp. 485–494, 2021. https://doi.org/10.1007/978-3-030-76352-7_44486 S. Asthana et al. enterprises operate in a multi-cloud environment. That is why different cloud vendors nowadays are	Ivon Miranda Santos

Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	Moving an application to the cloud enables organization to make use of the advantages of the cloud like elasticity [2], lower costs, and accessibility of data. To further utilize these advantages, achieve maximum flexibility, and avoid “concentration risk” (putting too many application eggs in one cloud basket), organizations recently tend to spread their	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	It is sometimes challenging to redesign the current IT infrastructure to meet the requirement before moving to the cloud. Cloud providers charge customers on a variable cost pay-as-you-go basis determined by the number of users and their volume of transactions [5]. Organizations are not readily willing to pay extra for the additional cost	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	Determining the cloud migration solution that agrees to all these requirements while still be applicable, is not trivial and cannot be achieved by non-analytical/manual ways. To overcome these drawbacks and challenges, we propose a methodology that rec-ommends the optimal set of cloud providers and creates a multi-cloud solution for the client. We evaluate the optimal set of cloud providers based on best the fit between recommendations from historical data as well as a decision optimization solution frame-work. We also provide recommendation for multiple applications at once instead of just one	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	2 Prior Art Prior research and analytical work of finding cloud providers using structured application data as well as optimizing cloud solution design together with migration have been done in this area. Pamami et	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	[7] shows a framework to create a generic reference for process of cloud migration while Iqbal et al. [8] discusses different cloud migration strategies and models, right from evaluating performance to choosing a cloud provider. Iyoob et	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	Yang [12] shows a hybrid cloud solution design for genomics Next Generation Sequencing (NGS) service, which is streamlined for this particular service. Megahed et al. proposes an optimal approach for cloud solution design that satisfies client requirements and cloud offering constraints for an application in [13, 14], though they do not account for the different constraints of choosing different cloud providers in the solution.Multi-cloud Solution Design for Migrating a Portfolio 487 Moreover, there is a numerous amount of prior art in applying analytical and opti-mization techniques to different cloud computing problems. For example, migrating vir-tual machines, applications	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	First, the time taken to gather all the features of the applications is quite inefficient, as it takes a lot of time and resources. Second, there is no analytical automated way of efficiently recommending a multi-cloud solution, where the current solutions rely on manual, inefficient evaluation of possible available cloud providers and thus requires a lot of back and forth with the client. That is, the prior art discussed above, as well as other works not reviewed above, focus on different aspects of cloud computing optimization	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	The output of this step is to come up with a rank of applications showing how feasible it is to move each application to the cloud. We evaluate the features of the applications and build a matrix of applications versus service cloud providers based on different factors such as cost, security features, service level requirements, etc. Lastly, we build an optimization model that finds the optimal set of solution providers for the	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	This inter-dependency as well as ranking of applications and application data enough to get a clear picture of the effort required to migrate the application to cloud, and its feasibility. Build a Matrix of Application versus Service Cloud Provider. In this step, using application features, we use a classifier model to categorize the applications into different categories–	Ivon Miranda Santos

Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	). After creating the weighting function, we can easily prepare a solution comprising of services from different cloud providers with minimum cost and maximum coverage of services. This is done by preparing a matrix of applications versus different service cloud providers on metrics like cost, QoS, coverage, security etc. as illustrated in Fig. 2. We build the matrix in a simplistic manner, where we take the available cloud providers as fields in the columns, and the different applications in the rows	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	In this step, we build an optimization model for the current set of applications. Here we try to optimize the cloud service providers based on constraints like:	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	is 1 if provider $j \in J$ is selected and zero, otherwise. The objective function minimizes the capacity of cloud provider selections and cost of application portfolio assignments. Besides the aforementioned constraints, other logical constraints are those assuring that each provider	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	We consider a large IT company with global employees across 20 countries, having up to ~100 applications that it wants to migrate to cloud. Here, we want to clarify that we do have the data from different cloud providers, based on services provided and have its metrics like coverage, QoS, security etc. We did not include all the details of	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	For our implementation, we first understood which applications should be moved to the cloud. We also documented the applications that should be grouped together under same cloud provider, and which applications should be kept separate from each other. There can be other constraints from the client like applications which can be under same cloud provider, but in different regions. We eliminated applications which cannot be moved to cloud	Ivon Miranda Santos
Asthana2021-Multi-cloud_Solution_Design_for_Migrating_a_Portfol	CLOUD SERVICE PROVIDERS > Cloud provider	This evaluation was used to rank how cloud feasible the application is. After eval-uating the cloud feasibility of the application, we built the matrix of application versus service cloud providers as shown in Fig. 4. Then, the optimization algorithm helped to optimize the recommended set of cloud providers which prepared the multi-cloud solution for the client. Providers	Ivon Miranda Santos
Aydin2021-A_Study_of_Cloud_Computing_Adoption_in_Universities_a	CLOUD SERVICE PROVIDERS > Cloud provider	In this way, users only pay for the cloud resources they use. The cloud conceptual reference model created by NIST contains elements that must be included in a cloud structure; these are “Cloud User,” “Cloud Controller,” “Cloud Service Provider,” “Cloud Agent,” and “Cloud Carrier” (Sevli, 2011). Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service	Ivon Miranda Santos
Aydin2021-A_Study_of_Cloud_Computing_Adoption_in_Universities_a	CLOUD SERVICE PROVIDERS > Cloud provider	In overcoming these challenges and providing an alternative way to operate information systems in a cost-effective manner, the role of cloud computing is great, especially for universities with budget shortages. Although personalized learning, being economic, elasticity, measurability, accessibility, low carbon emission, and standardization are shown as some benefits of cloud computing in the education field, security, compliance issue, lock-in, reliability, lack of skills, insufficient support of cloud service providers, policies on the cloud, privacy, and the complexity of cloud technologies are shown as some of its	Ivon Miranda Santos
Aydin2021-A_Study_of_Cloud_Computing_Adoption_in_Universities_a	CLOUD SERVICE PROVIDERS > Cloud provider	Thanks to cloud computing, institutions and organi-zations can use the computer resources they need without installing information systems, software, and hardware infra-structures within their own organization by sharing them as much as they need through cloud computing platforms. A cloud service user can receive and use the information service offered by another cloud service provider via cloud computing plat-forms. In such a case, there will be an increase in service diver-sity	Ivon Miranda Santos

Aydin2021-A_Study_of_Cloud_Computing_Adoption_in_Universities_a	CLOUD SERVICE PROVIDERS > Cloud provider	Participants were asked to identify obstacles of cloud computing for their universities (Figure 10). In all, 77.6% of the participants stated that “data security and confidentiality” and “dependency on the cloud service provider” were the most important obstacles of cloud computing. This was followed by obstacle perceptions related to “software security” (7.9%), “interoperability” (71.8%), “lCT resources” (70.6%), “legisla-tion and cost” (63.5%), “management support” (61.2%),	Ivon Miranda Santos
Baby2015-Multicloud_architecture_for_augmenting_security_in_clo	CLOUD SERVICE PROVIDERS > Cloud provider	As cloud computing service is a pay as you use service, it promises to reduce the initial capital investment as well as operational expenditures for hardware’s and software’s used in an organization [1]. Clouds can be classified based on the physical distance between the client and the cloud provider into public clouds, private clouds and hybrid clouds. If the cloud vendor is located far away from client it is termed as public cloud and if cloud vendor and client are in nearby premises it is termed as private cloud and if clients make use of both private and public clouds	Ivon Miranda Santos
Baby2015-Multicloud_architecture_for_augmenting_security_in_clo	CLOUD SERVICE PROVIDERS > Cloud provider	• Cloud Platform as a Service (PaaS): The user can utilize the programming language, libraries, services and tools supported by the cloud provider to deploy the applications[2]. The clients needn’t have any control over the infrastructure, storage or	Ivon Miranda Santos
Baby2015-Multicloud_architecture_for_augmenting_security_in_clo	CLOUD SERVICE PROVIDERS > Cloud provider	The data is not prone to any risks in case of failure as it is physically separated and protected independently. More importantly the cloud user has the choice of selecting the cloud vendor for storing data and application; a user may employ a specially trusted cloud provider for data storage and a different cloud provider for applications [3]. Other than the overhead of an additional cloud for computation, this architecture also requires a standard interface to correlate between the data	Ivon Miranda Santos
Baby2015-Multicloud_architecture_for_augmenting_security_in_clo	CLOUD SERVICE PROVIDERS > Cloud provider	The main advantage of this architecture is that every single cloud has only a partial view on the application and gains only limited knowledge [1]. Based on the application each cloud provider is assigned only subtasks on subset of data [2]. The main challenge for this approach is that there is no general format for splitting the logic and distributing among the clouds [6], therefore proper analysis of how the application logic can be divided among the clouds remain a headache for the users. The main two benefits in partitioning the application logic are, the cloud provider cannot understand the overall calculated result, and no cloud provider learns the application logic completely. Another main case where splitting of application	Ivon Miranda Santos
Baby2015-Multicloud_architecture_for_augmenting_security_in_clo	CLOUD SERVICE PROVIDERS > Cloud provider	This method guarantees secrecy of input data, unless the cloud providers decide to decrypt the data. A multiparty computation performs the computations in such a way so that no single cloud provider learns anything about the shared data.	Ivon Miranda Santos
Baby2015-Multicloud_architecture_for_augmenting_security_in_clo	CLOUD SERVICE PROVIDERS > Cloud provider	In vertical fragmentation the columns are split and distributed to the clouds such that no single cloud learns the relationship between the stored data. The main benefit here is that no cloud providers gain access to all data, thus maintains the confidentiality of data, however data that refers to real-time application can be understood by some external knowledge, therefore database splitting is also not a good solution for storing highly confidential information. In Cryptographic Data Splitting is, for better security the cryptographic key could remain with the user and make provision such that it is made	Ivon Miranda Santos

Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Keywords: Microservices Kubernetes Containers Orchestration Low-resource settings Portable cloud apps Cloud native platforms A B S T R A C T Developers and users situated in low-resource settings are faced with unique contextual and infrastructure challenges when accessing and consuming cloud-based services. In low-resource settings, access to cloud services and platforms is usually characterized by low-end computing devices and often unreliable and slow mobile broadband Internet connections. In this paper, we discuss key challenges for developing for and accessing cloud services in resource constrained settings, namely, (1) Frequent Internet partitions and bandwidth constraints, (2) Data jurisdiction	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	The results show lower response times of the system on Crane Cloud compared with hosting on other public clouds. The Crane Cloud platform is serving as a cloud-service for students and developers in low-resource settings and also as an education platform for cloud computing. 1.	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	The second assumption is that developers and users who consume cloud services have access to stable infrastructure to develop for or consume cloud-based services. From experiences developing for and consuming cloud services in low-resources settings, we find that these assumptions are not true. In such settings, challenges such as frequent Internet parti-tions, unannounced power shutdowns, poor quality of	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Other concerns include vendor lock-in, data security and protection, and price. Both users and developers situated in low-resource settings are	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	by the above challenges when developing or consuming the cloud-based services. With the increased reliance on digital services especially for the attainment of global Sustainable Development Goals (SDGs), addressing barrier to adoption of cloud computing services will be	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	The unanswered question is: How can cloud platforms be designed to facilitate seamless access to cloud-services for users and developers situated in low-resource settings? To address the above challenges and the arising research	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	1. Challenges and requirements for designing and operating a re-silient multi-cloud model for low resource settings. 2.	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Requirements for a custom cloud-service layer for low-resource settings As introduced above, low-resource settings are characterized by contextual challenges that present additional and new requirements for cloud platforms. To concretize these challenges, we use a real world scenario from low resource settings and present the requirements in Section 2.2.	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Motivating scenario The Automated Plant Disease Diagnosis (APDD) system is a real-world case study of a machine learning system used by African farmers and agricultural scientists in low-resource settings to diagnose plant diseases (Mwebaze and Biehl, 2016). Specifically, it is designed to pro-vide near real-time in-field diagnosis of plant diseases and identification of pests for cassava crops by farmers and agricultural experts in the East	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	The process flow typically involves uploading and downloading a huge datasets from the local storage and cloud systems. Such a dataset can take up to 24 h or so to upload to a public cloud service provider over slow intermittent connections that characterize many low-resource settings.	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	The process flow typically involves uploading and downloading a huge datasets from the local storage and cloud systems. Such a dataset can take up to 24 h or so to upload to a public cloud service provider over slow intermittent connections that characterize many low-resource settings.	Ivon Miranda Santos

Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Scenario analysis and requirements The above case study signals one of many other similar systems faced with technical hurdles when delivering cloud-based solutions in a low resource setting. To an extent, it reveals key requirements and challenges that can be addressed by containerized cloud-based systems that are	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	2.2.1. Frequent internet partitions and bandwidth constraints Whereas the main cloud providers have set up cloud services on stable infrastructure, developers and users situated in low resource settings face major constraints when accessing their hosted applications and cloud platforms. In such settings, access to cloud services and platforms is often through low-end	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	The in-field data collection by farmers to a public cloud repository can be very slow because of sporadic Internet connectivity in rural areas. Access speed to cloud services would be faster if the cloud data centers were located near to the users, however, 98.4% of the data centers of popular cloud providers are located overseas	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	The design and setup of most public cloud platforms assume stable infrastructure across the users and leave the issues of connectivity challenges to the applica-tion developers. This shifts the burden and unnecessary complexity to the application developers who must consider offering different function-trimmed variations of their app services for users situated in low-resource settings, for instance, Facebook Lite app (Shankar, 2015), WhatsApp Lite (DigitBin, 2019), Uber Lite (Uber, 2021), Google Go (Google LLC, 2019) and Gmail Basic (Google LLC, 2021) for slow Internet connections and low-end devices. The above issues form the motivation of the	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	For instance, the data storage and management microservice needs to be enforced to remain within the boundaries of the country while the plant disease prediction service can run in a public cloud without restrictions and benefit from the rich machine learning libraries and tools. Such a setup would require a multi-cloud environment that spawns boundaries with support for data jurisdiction policies specific to a microservice and use case. The popularity of cloud computing solutions has introduced gaps in key processes of the data management cycle (collection, storage, analysis	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	Most cloud solutions do not provide con-trols over where data should be stored and in cases where there is no infrastructure presence, users have to make exceptions at the expense of prescribed hosting recommendations. Cloud providers also distribute content over spatial infrastructure located in different regions to maintain the cloud Quality of Service (QoS) along dimensions of performance, availability and reliability. This leads to silos of data spanning different geographical	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	, 2013). These user categories may not have the local computing resources to run their workloads and most often resort to cloud providers but flexibility to switch/shift between providers is one of their desirable properties. Other than vendor lock-in, there are other variations including product lock-in, version lock-in, architecture lock-in, platform lock-in, skills lock-in and mental lock-in (Hohpe, 2019). Public clouds offer provider-specific proprietary solutions to meet the market demands and this has resulted in an interoperability, integration and portability downside across the cloud divide. Consequently, the applications developed for a specific cloud provider such as Amazon Web Services (AWS) may not work out-of-the box with another cloud provider such as IBM cloud due to inherent de-pendencies of the underlying IT infrastructure (hardware and software), cloud semantics and non-standardized APIs (Opara-Martins et al., 2016; Kratzke et al., 2014). The migration of cloud services from one provider to another usually requires major reworks on the application that may be catastrophic for mission-critical systems. For	Ivon Miranda Santos

Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	Furthermore, there are applications that are delay-sensitive and these require optimal and stringent quality of service parameter values such as low latency, low jitter and minimal or no packet loss for best performance. Currently, public cloud providers attempt to solve this challenge by moving services closer to the user. This approach however assumes presence of data centers closer	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Unfortunately this is not always the case for users located in regions where public cloud data centers are sparse. In the next section, we present the design options that need to be considered when developing a multi-cloud service abstraction layer to address the above challenges particularly in low resource settings. In the subsequent sections, we demonstrated the instantiation of the design	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	, 2017) but rather increased agility and reliability. In low resource settings, further automation of the containerization and deployment processes can ultimately enhance adoption of cloud computing (Mwotil et al., 2022).	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	Additionally, the replication approach in cases of downtime should consider the replication costs such as the impact on the network performance whenever provisioning is required. It should also be noted that the cloud service provider may impose restrictions based on, for example resource availability, which the user adheres to but regardless, the user will operate on a higher level of abstraction.	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	This is evidenced in the introduction of different cloud computing technologies and deployments to make it easy for organizations to embrace and adopt this new wave of handling com-pute, storage and network workloads. One of the pertinent issues in the adoption of cloud computing is vendor lock-in (lack of portability and interoperability across cloud platforms) where providers work with specific technologies such as tools and programming interfaces. Given the different deployment models and the cloud service models, orga-nizations should be able to move cloud services from one provider to another without worries of complexities and infrastructure dependence. Bozman and Chen (2010) identified standardized programming in-terface, abstraction layers and	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Service discovery and load balancing In a multi-cloud environment, applications may need to be scaled up by increasing application instances for improved user experience or scaled down by destroying excess instances to limit compute costs. In certain scenarios, an application may need to be moved from one cloud provider to another and rescheduled on a	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	In a multi-cloud environment, applications may need to be scaled up by increasing application instances for improved user experience or scaled down by destroying excess instances to limit compute costs. In certain scenarios, an application may need to be moved from one cloud provider to another and rescheduled on a particular node in the new location. In the process, application settings such as its Internet Protocol (IP) addresses and Domain Name Service (DNS) attributes may change and this necessitates an	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	In addition, an application with multiple instances of different services spread across different clouds requires an internal and external load balancer solution to prevent network and node overload which in turn translates to opti-mal usage of computing resources. The internal load balancers consider microservice communication inside a cluster (cloud provider) while external load balancers consider routing of client requests to	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	To fetch this image file, it will take close to 12 minutes and this can have a huge negative impact on the availability QoS requirement. To reduce container schedule (download) times, images may need to be distributed across different cloud providers and located very close to the container hosts.	Ivon Miranda Santos

Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	This section presents Crane Cloud, a first-cut prototype instantia-tion of design properties and considerations for a multi-cloud service layer presented in Section 3 and summarized in Table 1. Motivated by the unique requirements for low-resource settings in Section 2.2, Crane Cloud is an open source project that attempts to encapsulate the intricacies of operating heterogeneous application clusters into a highly available unified platform for management and monitoring of a microservice application lifecycle. The target users of the platform in-clude	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Architecture and overview Crane Cloud is an open source multi-cloud service layer designed to enable developers, organizations and researchers to set up reli-able cloud-services in low resource setting. The Crane Cloud software layer was conceived to address the key hurdles of operating a cloud-service platform in resource constrained environments	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	Multi-cloud cluster support Crane Cloud enables harmonization of clusters from different cloud providers (public or private) and bare metal environments. It is de-signed to provide for easy migration, replication and loadbalancing of services across different clusters and cloud providers to ensure high availability and improve the general user experience. The cloud providers are chosen based on location, API service offering	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Harbor35 perfectly fitted into the picture, providing an extensible API that the backend service would easily consume. Harbor delivers a consistent experience across multiple clouds and works best for environments that may not want to rely on public registries but rather a private one packaged as an add-on. Harbor additionally provides features such as access control on registry images, image vulnerability scanners, image	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	Harbor additionally provides features such as access control on registry images, image vulnerability scanners, image storage and replication using a clustering mechanism. Crane Cloud a is multi-cloud service layer that can work with cloud providers in different regions and availability zones and a zonal scalable registry with a replication service is cardinal.	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	This enables organizations to work with data-driven and legacy applications while leveraging the portability, scalability and highly available features of containers. Traditionally, Kubernetes used to provide support for manual attachment of cloud-backed storage to applications limiting usage outside the cloud provider but cloud native storage solutions have now been advanced. Crane Cloud uses OpenEBS,36 an open source Container Attached Storage (CAS) solution	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Low resource settings	Specifically we used JMeter tool to measure the response times of the two application setups against uploaded images over different mobile/wireless connections for a user situated in a bandwidth constrained setting. These testing settings and environments are a representative of the realities that developers and users working in the low-resource settings experience. On JMeter, four thread groups representing the image upload settings and two samplers (the two application setups: unet.mcrops.org and mcrops.cranecloud.io) were used as shown in	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	A1 11.23 22.90 35.70 22.90 6.91 10.78 18.03 11.66 B1 14.62 29.24 95.23 35.31 20.42 44.30 74.13 45.67 A2 26.01 43.61 89.97 46.93 36.74 51.36 67.07 51.31 B2 18.04 49.04 81.70 49.55 9.09 18.80 44.81 20.55 The results from this experiment show the response time patterns for applications and services hosted at cloud providers situated in rich-resource settings and accessed from varying resource constrained environments. The results are thus not specific a cloud provider, in this case AWS and the choice	Ivon Miranda Santos

Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Guerrero et al. (2018) presented an optimization approach to reduce service cost, microservices repair time, and microservices network latency overhead in the orchestration process of containers in multi-cloud envi-ronments using the scale level of the microservices and their allocation in the virtual machines, the provider and virtual machine type selection and the number of virtual machines. Sousa et al. (2016) developed a framework for automated deployment of microservice applications in multi-cloud environments with containers. The application's	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	3G connection test results. proper configurations that comply with the application's requirements and the cloud providers' constraints is adopted. Rancher40 and	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_service_abs	CLOUD SERVICE PROVIDERS > Cloud provider	The downside with these platforms is in addressing applica-tion requirements such as data processing and storage restrictions and the distinctive requirements for resource constrained settings. As more established cloud providers such as Microsoft, Google, Oracle and Ama-zon move towards hosted cloud-native platforms such as Kubernetes for easier configuration and management, the vendor-lockin issues are expected to exacerbate especially with no plans of integration tools or APIs. In summary, there is no standardized solution for implementation and operation of a multi-cloud service layer but rather	Ivon Miranda Santos
Bainomugisha2022-Crane_cloud_A_resilient_multicloud_s	CLOUD SERVICE PROVIDERS > Low resource settings	infrastructure which is not an option in a low resource setting and should be further explored.	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	There is a need for integrating multiple heterogeneous clouds and to solve the problem of distributing services over several providers [4]. Thus, in a scenario where a complex application is distributed on different cloud service providers, a solution is needed in order to manage and orchestrate the distribution of modules in a sound and adaptive way. Such solution should determine the best cloud provider for each particular module based on client requirements (e.g., performance,	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	O1) The orchestration and adaptation of services distributed over different cloud providers. SeaClouds aims at providing the assisted design, synthesis, and simulation of service orchestrations on cloud providers, distributing mod-ules from a cloud-based application over multiple and heterogeneous cloud offerings. O2) The monitoring and run-time reconfiguration operations of services dis-tributed over multiple heterogeneous cloud providers. Monitoring will be in charge of detecting the need	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	As a consequence of monitoring, dynamic reconfiguration will be used to evolve the orchestration by considering all the changes required (without suspending the execution of services not affected by those changes). Reconfiguration may imply updating a service, dynamically replacing erro-neous services or migrating them to a different cloud provider to leverage its advantages or avoid the shortcomings of another cloud provider. O3) The offer of unified application management of services distributed over different cloud providers. SeaClouds will be able to deploy, manage, scale and monitor services over technologically diverse clouds providers. Such operations will be performed taking into account the synchronization requirements of the	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	SeaClouds will address the following challenges in order to extend service-oriented approaches to the cloud: – Adaptation contracts need to take into account cloud providers characteristics and Service Level Agreement (SLA). – Violations of Quality of Service (QoS) properties need to be monitored across different cloud platforms. – Dynamic architecture reconfiguration might involve migrating some compo-nents of the application to other cloud providers at runtime. The latter two challenges (addressed by O2 and O3) are discussed in the	Ivon Miranda Santos

Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	Deltacloud (http://deltacloud.apache.org/) encapsulates the native API cloud provider to enable management of resources in differents IaaS clouds, such as Amazon EC2. Rightscale	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	//whirr.apache.org/) and Jclouds (http://www.jclouds.org/) that supports several IaaS providers. The already mentioned Cloud4SOA project also offers deployment and lifecycle management functionality using a harmonized API layer to encapsulate the providers APIs. Challenges in unified application management of services distributed over different cloud providers. SeaClouds will use Cloud4SOA's management	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	2.4 Standards for cloud interoperability CAMP (Cloud Application Management for Platforms) [5] aims at defining a har-monized API, models, mechanisms and protocols for the self-service management (provisioning, monitoring and control) of applications in a PaaS, independently of the cloud provider. However, CAMP is only a protocol specification, so it needs	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	The OASIS TOSCA (Topology and Orchestration Specification for Cloud Applications) [6] Technical Committee aims at enhancing the portability of cloud applications and services. The main aim of TOSCA is to enable the interoperable description of application and infrastructure cloud services, the relationships between parts of the service, and the operational behaviour of these services, independently from the cloud provider. By increasing service and application portability in a vendor-neutral ecosystem, TOSCA aims at enabling portable deployment to any compliant cloud, smoother migration of existing applications to the cloud, as well as dynamic, multi-cloud	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud architecture before and after SeaClouds.SeaClouds aims at homogenizing the management over different providers and support the sound and scalable orchestration of services across them. Moreover, systems developed with SeaClouds will inherently support the evolution of their constituent services, so as to easily cope up	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	High-level orchestration speci-fications will be used to describe the mapping between the services (dealt as modules that compose the cloud-based applications) to compose and the goal expected from their orchestration. This will ease the development of composite services since the developer does not need to deal with concurrency issues and will allow the process to be agnostic to the actual implementation	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Cloud provider	– Unified management API for clouds. SeaClouds facilitates the access and the administration of both public and private cloud providers providing multi-cloud management tools as well as offering cloud providers and consumers a REST-based approach to cloud-based application management. Using this API, SeaClouds can deploy, stop, start, and update applications, increasing consumers' ability to port their applications between cloud provider offerings. – Dashboard for administration of services	Ivon Miranda Santos
Brogi2014-Seaclouds_Seamless_adaptive_multi-cloud_management_of	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	SeaClouds facilitates the access and the administration of both public and private cloud providers providing multi-cloud management tools as well as offering cloud providers and consumers	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Current cloud technologies suffer from a lack of standardization, with different providers offering similar resources in a different manner [2]. This heterogeneity refers to diversities in supported programming tools, in the various types of underlying infrastructures, and even on available capabilities. As a result, cloud developers are often locked in a specific platform environment because it is practically unfeasible for them, due to high complexity and cost, to move their	Ivon Miranda Santos

Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	) are currently commercialising tools for the provisioning, management and automation of applications in leading public and private clouds. A promising perspective, opened by the availability of different cloud providers, is the possibility of distributing cloud applications over multiple heterogeneous clouds. Indeed, as pointed out by [8], cloud adoption will be hampered if there will be no suitable way of managing data and applications	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	In a scenario where a complex application is distributed on different cloud service providers, a solution is needed in order to manage and orchestrate the distribution of modules in a sound and adaptive way. Such solution should determine the best cloud provider for each particular module based on client requirements (e.g., availability,	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	More specifically: O1) Orchestration and adaptation of services distributed over different cloud providers. SeaClouds aims at providing the assisted design, synthesis, and simulation of service orchestrations on cloud providers, distributing modules from a cloud-based application over multiple and heterogeneous cloud offerings. O2) Monitoring and run-time reconfiguration operations of services distributed over multiple heterogeneous cloud providers. Monitoring will be in charge of detecting the possible need of redistributing services on several cloud providers. As a consequence of monitoring, dynamic reconfiguration will be used to evolve the orchestration by considering all the changes required. Reconfiguration may imply updating a service, dynamically replacing malfunctioning services or migrating them to a different cloud provider to leverage its advantages or avoid the shortcomings of another cloud provider. O3) Offer unified application management of services distributed over different cloud providers. SeaClouds will be able to deploy, manage, scale and monitor	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	The rest of the paper is organized as follows. Section 2 will introduce a motivating example to illustrate the problems occurring when deploying an application on multiple cloud providers. Section 3 will position SeaClouds with respect to current cloud initiatives and single out the main challenges	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	2 Motivating Example In order to motivate our proposal, we introduce an example where a multi-component application is going to be deployed on (potentially) different cloud providers, according to a number of requirements on each of the modules composing the application. After the (multi-cloud) deployment is performed, and components are being executed in different cloud platforms, a monitoring process is in charge of detecting possible requirements	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	• Some of the cloud platforms possibly fail. The original cloud provider claims high availability rates but their services are not entirely exempt of failures.	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Resources transparently scale as need, but this may provoke cost spikes. • The business model of the original cloud provider changes (volatile market). The application hosted on that cloud provider could require rearranging it to exploit services, platforms and infrastructures which present the most beneficial cost/value ratio. Considering the changing situations listed above, the application manager would need to have some modules of the application being moved from the platforms in which they were originally deployed to other platforms. To this end, the SeaClouds platform will provide monitoring facilities allowing the user to observe a set of standardised and unified metrics of different types, based on	Ivon Miranda Santos

Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Several approaches exist that target formal verification and adaptation of orchestrated services, but, to the best of our knowledge, none of these approaches has been extended to the cloud environment. Challenges such as heterogeneity of cloud platforms and migration to different cloud providers have to be addressed, as well as the different standards emerging from distinct vendors. Therefore, existing approaches	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	SeaClouds will address the following challenges in order to extend service-oriented approaches to the cloud: • Adaptation contracts need to take into account cloud providers characteristics and Service Level Agreement (SLA). • Violations of Quality of Service (QoS) properties need to be monitored across different cloud platforms. • Dynamic architecture reconfiguration might involve migrating some components of the application to	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	The EU FP7 Cloud4SOA project (http://www.cloud4soa.eu) provides an open source interoperable frame-work for application developers and PaaS providers. Cloud4SOA facilitates developers in the deployment and lifecycle management and monitoring of their applications on the PaaS offering that best matches their computational needs, and ultimately	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Deltacloud (http://deltacloud.apache.org/) encapsulates the native API cloud provider to enable management of resources in differents IaaS clouds, such as Amazon EC2. Rightscale	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	//www.newrelic.com). NewRelic achieves platform-independency by requiring each provider to implement a monitoring component and to integrate it in the offered cloud platform. On the one hand, this approach yields the best results	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	The already mentioned Cloud4SOA project also offers deployment and lifecycle management functionality using a harmonized API layer to encapsulate the providers APIs. Challenges in unified application management of services distributed over different cloud providers SeaClouds will use Cloud4SOA's management functionality.	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	• SeaClouds management will use the REST harmonized API for the deployment, management and monitoring of simple cloud-based applications across different and heterogeneous cloud PaaS offerings. SeaClouds intends to use Brooklyn's policy-driven functionality to integrate support for IaaS providers. Moreover, Brooklyn's approach to policy modeling and enforcing can provide	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	3.4 Standards for cloud interoperability CAMP (Cloud Application Management for Platforms) [4] aims at defining a harmonized API, models, mech-anisms and protocols for the self-service management (provisioning, monitoring and control) of applications in a PaaS, independently of the cloud provider. However, CAMP is only a protocol specification, so it needs to be	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	The main aim of TOSCA is to enable the interoperable description of application and infrastructure cloud services, the relationships between parts of the service, and the operational behaviour of these services, independently from the cloud provider [17]. By increasing service and application portability in a vendor-neutral ecosystem, TOSCA aims at enabling portable deployment to any compliant cloud, smoother migration of existing applications to the cloud, as well as dynamic, multi-cloud provider applications.	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_application	CLOUD SERVICE PROVIDERS > Intracloud and federation	In the same scope of SeaClouds' approach, Cloud Federations have gained momentum in the last	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Intracloud and federation	A Cloud Federation, in the sense of inter-cloud operation, is a platform where the user can select the infrastructure in which to deploy her software across a set of third-party solutions.	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Intracloud and federation	On the one hand, one example is AppFog, a kind of Cloud Federation, whose system enables the user to select the infrastructure on which her software is going to be deployed among several	Ivon Miranda Santos

Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud architecture before and after SeaClouds. SeaClouds aims at homogenizing the management over different providers and at supporting the sound and scalable orchestration of services across them. Moreover, systems developed with SeaClouds will inherently support the evolution of their constituent services, so as to	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Increased availability and higher security. The usage of formal models to support the management of service-based applications over multi-clouds environments gives more flexibility to reconfigure the distribution as a SLA violation occurs.	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	CLEI ELECTRONIC JOURNAL VOLUME 18 NUMBER 1 PAPER 1 APRIL 2015 crawls the cloud providers and stores the discovered capabilities in a repository which is accessible to the Planner component as well as to the Deployment Manager.	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	On the other hand, SeaClouds also employs CAMP, which proposes standardised artifacts and APIs that need to be offered by PaaS clouds to manage the building, running, administration, monitoring and patching of applications in the cloud. It is however worth noting that the Deployer does not require cloud providers to be TOSCA or CAMP compliant, and it actually generates concrete deployment plans for non TOSCA/CAMP compliant providers as needed.	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	The SLA Service is in charge of mapping the low level information gathered from the Monitor into business level information about the fulfilment of the SLA defined for a SeaClouds application. It is responsible for establishing, reviewing and cancelling of complex end-to-end- Service Level Agreements (SLAs) between Application Providers and Cloud Suppliers. It covers the complete SLA and service lifecycle with consistent interlinking of planning and runtime management aspects by implementing procedures and	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Before concluding this presentation, let us briefly mention some other important aspects of the architecture: the Discoverer component also makes use of OASIS CAMP, to access the capabilities featured by (CAMP compliant) cloud providers. The Discoverer, the Deployer and the Monitor rely on CAMP-compliant adapters to	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	As described previously, cloud computing has proven a major commercial success in the last years, with the appearance of many different vendors. What followed is a need for integrating multiple heterogeneous clouds and to solve the problem of distributing the services over several providers. In particular, the need of orchestration is more evident when complex applications move	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Example of SeaClouds multi-cloud deployment for the online retailing system. complex application is distributed on different cloud service providers, a solution is needed to manage and orchestrate the distribution of modules in a sound and adaptive way. The SeaClouds platform is proposed to solve these problems and advance the field by supporting the orchestration and deployment to multiple clouds and management thereon, including resilience and migration of modules that compose cloud-based applications over multiple	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	This allows organisations to embrace cloud solutions and avoid risks of unreliability and vendor lock-in. By solving the problems caused by the multiple-vendor scenario, the SeaClouds architecture would benefit not only application developers and cloud providers, but also the whole market, by reducing the adoption barrier for new players.	Ivon Miranda Santos

Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	In the SeaClouds platform, the newly emerged OASIS standard TOSCA is employed to specify the topology of complex applications. TOSCA enables the interoperable description of application and infrastructure cloud services, the relationships between parts of the services, and the operational behavior of these services, independently from the supplier creating the services, and any particular cloud provider or hosting technology. In line with the main goals of TOSCA [17], the use of this standard will ease automated deployment and management, and will enhance the portability and reusability of multi-	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	extending and incorporating CAMP, we can cover all future CAMP-compliant providers or tools, allowing application developers to manage applications hosted on multiple clouds environments. Furthermore, by leveraging CAMP, SeaClouds will attract a significant user base (as this standard has a lot of interest but no reference implementations, so far) and advance the standard, ensuring the long-term viability of the benefits implied in SeaClouds, i.e., management and monitoring of underlying providers, performance optimisation, low impact on the	Ivon Miranda Santos
Brogi2015-Adaptive_management_of_applications_across_multiple_c	CLOUD SERVICE PROVIDERS > Cloud provider	Please note that, thanks to the seamless distribution over several different PaaS platforms, applications developed in SeaClouds will also take advantage of higher availability (via inter-PaaS redundancy), higher security (via inter-PaaS data partition) and higher throughput (via inter-PaaS load balancing). A key ingredient in our proposal is the use of two OASIS standards initiatives for cloud interoperability, namely CAMP and TOSCA, which allow us to describe the topology of user applications independently of cloud providers, provide abstract plans, and discover, deploy/reconfigure, and monitor our applications	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	Abstract— Cloud computing provides convenient access to abstract computational resources over the Internet. In addition to common services like virtual machines, cloud providers are offering own proprietary domain-specific services and frameworks. The absence of common standards and interfaces makes it difficult to connect services of different clouds, migrate between	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	Every offline business aimed to “move online” during lockdowns, which demonstrated cloud capabilities in new business areas. Cloud providers such as Microsoft, Amazon Web Services, Alicloud and Google Cloud Platform have grown their revenues between 25% and 100% [2]. This growth has shown enduring business change at scale and speed, and forecasts say that it will continue. This article describes emerging architectures of cloud infrastructure that give customers flexibility to use more services than a single cloud provider offers. Each architecture allows a certain degree of multi-	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	There was also a significant shift on a technical side of a digital business transformation. Previously, an application developer would select one cloud provider and make use of its integrated set of services and APIs, combining it with on-premises legacy systems, if business had any. However, as providers have been investing more effort into development of niche-focused services, developers need to use new cloud architectures	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	When mentioning cloud heterogeneity, various articles may interpret this term in different ways. On a lower level, heterogeneity means that different types of processors are combined to provide virtualized heterogeneous hardware within a single cloud provider. On a higher level, heterogeneity is meant in the context of multi-	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Intracloud and federation	Cloud federation enables end users to integrate segregated resources from different cloud	Ivon Miranda Santos

Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	Federated cloud would typically offer different services of different vendors. By using cloud provider APIs, organizations can adjust their cloud plan using different service vendors, according to their needs. Federated clouds are connected on same layers as Hybrid clouds, having same difficulty of	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	It is a complicated issue since new resources are frequently added to the cloud marketplace, while there are no UDDI-like catalogues which report all resources available for usage. • Different abstractions: all common abstractions, which includes storage and network architectures would vary across cloud providers, which makes the use of multi-cloud a specific task for each application rather than using a generic platform or service. • Different billing: models for user billing differ significantly across cloud providers, making it close to impossible to dynamically estimate cost of the same task running on one cloud or	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	According to previous research made in [20], possible solutions for cloud interoperability can be divided in two directions: user-centric and provider-centric: • Provider-centric approaches rely on cloud providers willingness to implement specific standards to achieve interoperability. • User-centric approaches rely on practical solutions on users side and dont depend on cloud providers agreements. Instead of cloud providers, all interoperability implementation effort is handled by in-house IT staff.	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	Since there is no common registry or standard interfaces for discovery and service integration, it is technically impossible to propose any fully automatic integration scenario. However, common use of HTTP APIs across services of different clouds providers lets us to partially define the integration model relying on HTTP as a standard connecting interface.	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	This approach is top to bottom – rather than building a complex common foundation meant to integrate all of the layers on top of it, we take the most common integration interface on top of the stack (application level), develop common patterns that would assist integration, and connect services as required further down the stack. Since we operate on plain HTTP protocol for interconnecting clouds, provider-specific service APIs still have to be implemented manually for integration. However, as a fully manual implementation is already the most common scenario of cloud integration in the industry, even a partial automation would be a significant step forward. Considering the speed at which cloud providers deliver new products, it is unrealistic to create and maintain an API registry covering all public services, as proven by abandoned attempts of global UDDI registries deployment. However, we can partially automate connecting most popular serverless services across cloud platforms by creating domain-specific ontological models and developing integration patters related to them,	Ivon Miranda Santos
Caceres2022-State-of-the-art_architectures_for_interoperability	CLOUD SERVICE PROVIDERS > Cloud provider	However, this workaround cannot fully integrate cloud-native IAM tools that cloud providers offer. The next research step in this direction is creating abstract ontology models, specific to cloud providers and domain of use. Then, extracting common patterns and implementing them, and evaluation of the automation level possible with	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	Finally, the existence of different providers allows clients to pick the one that makes room for the best value for their money, depending on their requirements and needs. Both the cost reduction and the high demand by clients represent an opportunity that lead to the multiplication of cloud providers. Services like Cloud XL[2] list more than 300 providers	Ivon Miranda Santos

daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	The main consequence of this heterogeneity is the so-called vendor lock-in, i.e. clients are “locked into” providers solutions just because migrating to different providers would cost too much to them. The main preoccupation of clients is then designing applications that are less tied to specific cloud providers as possible and that can be monitored and provisioned in cloud provider independent ways. Special attention also needs to be paid to the data structures used to design	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	In order to help us in making this transition, we are taking part of the MODAClouds project. This project intends to develop the designing and runtime tools necessary to allow us to design our application on a cloud provider independent way, avoiding the pitfalls of the vendor lock-in. In this paper, we describe our baseline modelling services and our plans to migrate them to the	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	One of the objectives of SOFTEAM in moving these services to the cloud is to relieve the burden for our clients in supporting this infrastructure. We hope that the “potentially infinite” resources available on the cloud will make tasks such as scaling the servers of a project up and out and moving between different cloud providers very easy to our customers. Additionally, activities such as monitoring and adapting the installation hopefully will be able to	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	should keep uniform availability levels to our customers independent of the peaks of demand on the cloud servers, which may vary from a day to another or from a week to another. In order to maintain an acceptable QoS level for the environment, we should therefore be able to identify these peak demand periods and predict the next ones so that project servers can be endowed with more computing resources or moved to another cloud provider supplying more resources. In the following list, we provide the high-level	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	Clients should be able to supervise the availability and performance of their subscribed services and to adapt the deployment of services to their needs by means of an administration environment. By adapting we mean moving projects from one node to another or even from one cloud provider to another. Clients should be able to purchase a specific level of service to be delivered by the Project Management Server (e.g. buying more or less processing power or memory or storage space for ones projects, or the number of allowed	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	These resources may, potentially, live in different cloud platforms. 2) Frameworks and cloud provider independence Deployment on IaaS platforms or PaaS platforms that support common standard deployment formats such as the JEE application (Heroku,...).	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	It is this service that allows the management of projects on the cloud to be accomplished in a transparent way to the users. This service should therefore interact with the cloud providers in order to deploy the Remote Fragment Service and the Modelling Conference Service and to make them available to users. In a situation in which the contracted service level is not being respected, the Administration Service may allocate additional resources at a cloud provider and deploy new instances of the deficient services, or reduce the number of existing resources accordingly. It should also be able to move resources or projects from one service to another, or from one	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	The architecture of the Administration Service The only dependency of this design to the specific cloud provider is the communication between the Administration Service and the cloud provider in order to deploy, monitor and eventually migrate services. The actual code to interact with the cloud provider is however encapsulated in a Web Service usually installed on the Administration Service. This Web Service translates actual requests from the user into specific requests to the cloud provider.	Ivon Miranda Santos

daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	We intend to implement them during the MODAClouds project. During this project we also intend to make its implementation cloud provider independent. Even though our current prototype uses the Amazon AWS API that allows it to run either on the public Amazon EC2 cloud and on our private Eucalyptus based cloud, it only supports one cloud at a time, namely, the one on	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	There are however still open questions that we are yet not able to answer with the currently existing tools and that we hope to have solved by the means of the MODAClouds project: How to monitor the quality of the provided service in a cloud provider independent way? When and how to tweak the deployment to achieve the desired QoS? Which cloud provider/resource kind can run our services in a cost effective way? What is the cost of migrating/running our	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	These approaches are not applicable to our case because we already have a prototype that is cloud-enabled, and most of these approaches do not provide any answer to our concerns related to cost analysis and data design. They also preconize the refactoring of an application to a specific cloud, while we try to achieve the design of an application that is cloud provider independent, by means of the use of standard protocols and APIs. The second category of approaches is represented by the unifying APIs like the ones provided by the	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	Restrictions apply.The MODAClouds project intends to avoid these pitfalls by providing the necessary tools for designing and running cloud applications in a cloud provider independent way. The current paper described ModelioSaaS, one of the case studies of the MODAClouds project. This case study, provided by SOFTEAM, a French medium sized company, illustrates the challenges involved in migrating web based services to the cloud while preserving cloud provider independence. As this project is still in its initial phase, the main contribution of this paper is not in describing a fail-	Ivon Miranda Santos
daSilva2013-From_the_desktop_to_the_multi-clouds_The_case_of_mo	CLOUD SERVICE PROVIDERS > Cloud provider	Throughout the MODAClouds project, SOFTEAM intends to implement and validate the architecture presented in the present paper. The MODAClouds technologies will hopefully help to provision and monitor all cloud-based services, as well as, if necessary, to migrate them from one cloud provider to another. In this paper we have also described the remaining challenges, related to designing, and provisioning cloud applications that are still to be tackled throughout the	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	PacificClouds: A Flexible MicroServices based Architecture for Interoperability in Multi-Cloud Environments	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	While the cloud brings several benefits, there are still some challenges that need to be overcome to apply the cloud model in certain scenarios. One such problem is the so-called vendor lock-in since different cloud providers offer peculiar and often incompatible services, which results in the automatic migration impossibility of the application between cloud providers. This issue becomes even more problematic when thinking of future applications composed of services or components hosted by different cloud providers in a multi-cloud environment. Dealing with ven-dor lock-in in multiple clouds requires addressing two important	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	One such problem is the so-called vendor lock-in since different cloud providers offer peculiar and often incompatible services, which results in the automatic migration impossibility of the application between cloud providers. This issue becomes even more problematic when thinking of future applications composed of services or components hosted by different cloud providers in a multi-cloud environment. Dealing with ven-dor lock-in in multiple clouds requires addressing two important	Ivon Miranda Santos

deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Some solutions have been proposed to deal with both problems, but most of them fail to provide flexibility. Therefore, we propose PacificClouds, a novel architecture based on microservices for addressing interopera-bility in a multi-cloud environment. PacificClouds differs from previous works by providing greater flexibility due to the	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	, 2009). Facing the cloud computing's success, cloud pro-viders proliferate rapidly; each one them wants to of-fer infrastructure, platform, and services to satisfy the needs of its users in such a manner that they do not want to use other providers. The infrastructure and services of a	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	Therefore, providers become considerably specific. Thus, the problem known as vendor lock-in arises as a consequence the user applications are dependent on a single cloud provider	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	One method for treating vendor lock-in is the use of multiple clouds, although a small number of enterprises adopt this approach, their popularity is increasing. One reason for the low adoption of multiple clouds is cloud providers interest lack to promote interoperability and portability (Grozev and Buyya, 2014). According to this context,	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Carvalho, J., Trinta, F. and Vieira, D. PacificClouds: A Flexible MicroServices based Architecture for Interoperability in Multi-Cloud Environments. In Proceedings of the 8th International Conference on Cloud Computing and Services Science (CLOSER 2018), pages 448-455	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	In Section 3, we describe, present challenges and propose a definition for microservices. In this work, we propose a novel architecture ba-sed on microservices to address interoperability for a multi-cloud environment, called PacificClouds, in or-der to mitigate vendor lock-in and aid to obtain full cloud advantages. PacificClouds promotes flexibility for user's decisions related to requirements and ap-plication architecture, and for choosing the clouds to execute each microservice	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	PacificClouds. PacificClouds is flexible as it allows the use of several independent cloud providers. The providers can use different technology backgrounds and let software architects utilize several techniques in developing the applications, update the software and the user and ap-plication requirements at	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	According to the context aforementioned, the contributions of this article are given below: • The proposition and description of PacificClouds, a novel architecture, which provides greater ease in the development of native cloud application, and more flexibility in the deployment and execution of an application in multiple clouds environment because of microservice use. • A more comprehensive definition of microservice.	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	2 MULTIPLE CLOUDS Multiple clouds enable applications to take advantage of the best features of different components provided by several cloud providers. Since there is still no stan-dardized taxonomy for the subject, different terms are used in the literature and they often have the same meaning	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	In this work, we adopt the definitions used by (Petcu, 2014b), who classifies different multiple cloud application scenarios as delivery models and presents three main proposals for these models. The first, cal-led multi-cloud, is a delivery model that does not in-clude a prior agreement among the cloud providers, a third party assumes the role of intermediary. In a cloud federation, the second delivery model exists as an established collaboration arrangement among cloud providers to share their resources. The third delivery model, called inter-cloud, can be on both a cloud federation and multi-cloud, but the scalable and opportunistic services must be dynamic, and inter-cloud must possess the cloud broker, which is an in-termediary actor in the relationship between the pro-vider and the consumer. The use of multiple clouds brings several advantages, and through them, we can achieve the full	Ivon Miranda Santos

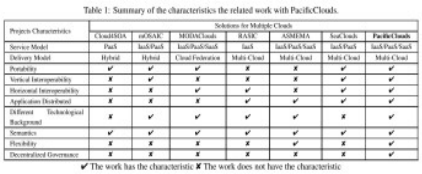
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Intracloud and federation	In a cloud federation, the second delivery model exists as an established collaboration arrangement among cloud providers to share their	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Intracloud and federation	The third delivery model, called inter-cloud, can be on both a cloud federation and multi-cloud, but the scalable and opportunistic services must be dynamic, and inter-cloud must possess the cloud broker, which is an in-termediary actor in the relationship between the pro-vider and the	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	PacificClouds: A Flexible MicroServices based Architecture for Interoperability in Multi-Cloud Environments 449	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	PacificClouds: A Flexible MicroServices based Architecture for Interoperability in Multi-Cloud Environments 451	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	4.2.5 Deployment Plan Generation Service The Figure 6 illustrates Deployment Plan Generation Service (DPGS), which determines the cloud provi-ders for deploying the microservices without viola-ting application and user requirements via Cloud Se-lection Service (CSS). For this, it receives from the SLA Service	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Cloud provider	The RA-SIC focuses on resolving the semantic interoperabi-lity issues in IaaS and introducing a user-centric ap-proach for applications that use cloud resources. It fa-cilitates the smooth switching among cloud providers and allows the composition and services integration of different clouds (Loutas et al., 2010). Automated Setup of Multi-Cloud Environments for Microservices Applications proposes an automa-ted approach for the selection and configuration of cloud providers for microservices based applications. But it does not deal directly with applications deploy-ment and does not consider costs and quality of ser-vice for optimizing the	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	, 2010). Automated Setup of Multi-Cloud Environments for Microservices Applications proposes an automa-ted approach for the selection and configuration of cloud providers for microservices based applications. But it does not deal directly with applications deploy-ment and does not consider costs and quality of ser-vice for optimizing the selection as these depend he-avily on application	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Intracloud and federation	Despite addressing the three levels, MODA-Clouds only addresses horizontal interoperability	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Intracloud and federation	Cloud4SOA addres-ses interoperability at the PaaS level; it does not ad-dress any vertical and horizontal interoperability le-vels, and it uses the hybrid delivery model, which is a cloud federation that has a private cloud and at least one public	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	PacificClouds: A Flexible MicroServices based Architecture for Interoperability in Multi-Cloud Environments 453	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Therefore, Paci-ficClouds is the only proposed solution that promo-tes the decentralized governance of the applications, to the best of our knowledge, allowing the applica-tion modules to have a loosely coupled, in addition to generating less traffic in the network and therefore allowing greater flexibility. According to the analysis performed in this sub-section, we can observe that PacificClouds allows gre-ater flexibility regarding interoperability in a multi-cloud environment. Because of allowing an applica-tion to be distributed over several clouds according to the requirements of the application and the user re-gardless of the technology used,	Ivon Miranda Santos
deCarvalho2018-Pacificclouds_A_flexible_microservices_based_arc	CLOUD SERVICE PROVIDERS > Intracloud and federation		Ivon Miranda Santos

Table 1: Summary of the characteristics the related work with PacificClouds.

Projects Characteristics	Solutions for Multiple Clouds						
	CloudMIDA	mOSAIC	MODAClouds	RASIC	ASIMEMA	SeaClouds	**PacificClouds**
Service Model	PaaS	IaaS/PaaS	IaaS/PaaS/SaaS	IaaS	IaaS/PaaS/SaaS	IaaS/PaaS	IaaS/PaaS/SaaS
Delivery Model	Hybrid	Hybrid	Cloud Federation	Multi-Cloud	Multi-Cloud	Multi-Cloud	Multi-Cloud
Portability	✔	✔	✔	✘	✘	✔	✔
Vertical Interoperability	✘	✔	✘	✘	✘	✔	✔
Horizontal Interoperability	✘	✘	✔	✔	✘	✔	✔
Applications Distributed	✘	✘	✘	✔	✔	✔	✔
Different Technological Background	✘	✔	✔	✔	✔	✘	✔
Semantics	✔	✔	✔	✔	✔	✔	✔
Flexibility	✘	✘	✘	✘	✔	✘	✔
Decentralized Governance	✘	✘	✘	✘	✘	✘	✔

✔ The work has the characteristic ✘ The work does not have the characteristic

dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	However, the identification of opportunities for migration, the reasoning of an attractive cost-benefit relation-ship and the selection of service providers that best fit their needs are not trivial tasks [16,17]. The selection of commercial cloud providers is a challenging task and depends on several variables and indicators. Among other reasons, cloud providers may continually upgrade their hardware and software infrastructures, and new commercial Cloud services, technologies and	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	This paper has three major contributions: (i) the identification of strategies and issues that companies have considered to migrate to the cloud; (ii) factors that should be considered in the cost-benefits relationship while adopting and migrating to the cloud; (iii) and finally aspects related to the selection of cloud computing service providers.	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	These three services described above are deployed following four different models: (i) Public cloud is available from a third party service provider via web and is a very cost effective option to deploy IT solutions [20]; (ii) Private cloud is managed within an organization and is suitable for large enterprises (managed within the walls of the enterprises). Private clouds provide the advantages of public clouds, but still incur capital expenditures [20]; (iii) Community cloud is used and controlled by a group of enterprises, which have shared interests [20]; (iv) Hybrid cloud is a combination of public and private cloud [20]. This	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	RQ3. How companies select cloud computing service providers according to their needs and profile? The knowledge of successful strategies and problems raised by inappropriate selection of CC providers allow organizations to be more confident to identify providers that best fit their	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	This tool has been recognized as an important reference for benchmarking. To this end, it identifies a common set of services offered by cloud providers, including elastic computing, persistent storage, and intra-cloud and wide-area networking. The authors argue that CloudCmp enables predicting application performance	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	F. de Carneiro onto every cloud provider. The paper [S57] with 279 citations according to Google Scholar, proposes a framework and a mechanism to measure the quality and prioritize Cloud services providers. According to the authors, given the diversity of Cloud service offerings, an important challenge for customers is to find out appropriate Cloud providers that can satisfy their requirements (RQ3). This makes it difficult to evaluate service levels of different Cloud providers, justifying the use of a Analytical Hierarchical Process (AHP) based ranking mechanism to provide a quantitative basis for the ranking of Cloud services where the final ranking is based on the cost (RQ2)	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	The study [S21] presented a generic framework to support the migra-tion of live media streaming to a cloud platform, fundamental understandings on the practical feasibility and theoretical constraints in the migration are also discussed. According to the authors, extensive simulations driven by traces from both cloud service providers (Amazon EC2 and SpotCloud) as well as a live media streaming service provider (PPTV) to demonstrate the cost-effectiveness and superior streaming quality of CALMS, even with highly dynamic and global-ized demands. [S23] proposed a set of migration patterns which span the contin-uum from legacy IT environment to the cloud is included as a common	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	[S44] used small case study to show that application performance doesn't deteriorate when migrating applica-tions to the cloud. [S45] abstracts from current market prices and investigates the interaction of cloud provider and clients from an analytical perspective. A general understanding of how providers and clients potentially benefit finan-cially from Infrastructure-as-a-Service (IaaS) can help clients to appraise	Ivon Miranda Santos

dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	The paper proposed a model that helps not just identify the suitability of a company for the cloud by clearly spelling out all the factors that need to be considered for the same, but also gives a certain profitability valuation of the benefits associated with CC. An approach to detect performance anti-patterns before migrating to CC based on static analysis was presented in [S12]. In [S4], the architectural features of CC are explored and classified according to the requirements of end-users, enterprises, and cloud providers themselves to support the cloud adoption. The [S2] study described the Cloud Adoption Toolkit	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	A Systematic Literature Review on Cloud Computing 237 4.3 Selecting Cloud Computing Service Providers (RQ3) This subsection discusses how selected papers addressed RQ3: How companies select cloud	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	[S46] proposed a framework to incorporate a modelling language and also provided a structured process to support elicitation of security and privacy requirements. The goal was to select a cloud provider based on the suitabil-ity of the service provider to the relevant security and privacy requirements. The authors of paper [S47] performed a survey to obtain Cloud service selec-tion approaches from companies considering five perspectives: decision-making techniques; data representation models; parameters and characteristics of Cloud services; contexts, purposes. [S48] highlighted the importance of an informed choice of a Cloud Service Provider (CSP) in minimising one's exposure to the insecurity of a cloud context and proposed a well-	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	The tool is build upon and significantly extends the cloud simulator CloudSim and integrates into the cloud migration framework Cloud-MIG. [S55] the tool CloudCmp to systematically compare the performance and cost of cloud providers along dimensions that matter to customers. This sys-tematic review provided evidences of strategies used by companies to identify opportunities to migrate and adopt cloud computing, how they assess the cost-benefit relationship and strategies behind the rationale to select providers. A spectrum of techniques and approaches has been	Ivon Miranda Santos
dePaula2016-A_systematic_literature_review_on_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	One of the main contribution of this paper was also the discussion of a list of approaches published in the lit-erature that deal with the cost-benefit relationship and the rationale behind the selection of providers and their respective services. We are already investigating how providers have perceived the clients adoption and migration to the cloud computing paradigm and how they tailor their strategies to meet the needs of customers. We have already performed the snowballing technique considering the selected papers of this SLR to increase the list of papers	Ivon Miranda Santos
Elmroth2011-Self-management_challenges_for_multi-cloud_architec	CLOUD SERVICE PROVIDERS > Cloud provider	Recent advantages in virtualization combined with multi-tenancy enables cloud infrastructure providers to perform large-scale provisioning of compute or data intensive services. Such a cloud appears to the service (content) provider as a sin-gle system always delivering sufficient capacity, where service capacity also can be increased or decreased rapidly to meet workload fluctuations. Despite these recent advances significant	Ivon Miranda Santos
Elmroth2011-Self-management_challenges_for_multi-cloud_architec	CLOUD SERVICE PROVIDERS > Cloud provider	In par-ticular, following Ferrer et.al. [14], we address bursted private clouds (a service provider having a private cloud infrastructured with possibility to expand using external clouds), federated clouds (infrastructure providers using partners to en-sure the capacity needed to serve the service providers that are their customers), and multi-clouds (service providers working directly with multiple external in-frastructure providers). The management challenges in focus are not specific to any of the scenarios, but are rather derived from a single cloud deployment ab-	Ivon Miranda Santos

Elmroth2011-Self-management_challenges_for_multi-cloud_architec	CLOUD SERVICE PROVIDERS > Cloud provider	An opportunity for providers, but also a complicating factor is that not only service capacity demand varies over time but also available resources. Cloud federation and cloud bursting may allow an infrastructure provider to aquire additional server resources from other	Ivon Miranda Santos
Fowley2018-Cloud_migration_architecture_and_pricing_–_Mapping_a	CLOUD SERVICE PROVIDERS > Cloud provider	For instance, pattern-based migration processes are suggested to organise and manage the architectural migration. Tools have been provided by many cloud service provider to migrate for instance data using data loaders. In [21], the top 10 challenges for start-ups are summarised, that also reflect the concerns for migrations by software vendors inexperienced in cloud technolo-gies, particularly if the cloud context	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Legacy applications often predate the cloud computing and thus have been developed without taking into account the characteristics of cloud environments. The complexity of migration is exacerbated by the fact that some legacy applications may have been developed without taking into account the unique requirements attributed to cloud environments such as elasticity, multi-tenancy, interoperability, and refactoring. Such requirements raise new challenges to the migration of applications to the cloud and hence needs improving conventional software	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	(i) resource elasticity, (ii) multi-tenancy, (iii) interoperability and migration over multiple-clouds, (iv) application licensing, (v) dynamicity and unpredictability, and (vi) legal issues. These concerns trigger considerations that an application owner should consider them in the migration process, though they might have been already automatically supported by cloud providers. The remainder of this section delineates	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Multi-tenancy is an ability to use the same instance of a resource at the same time by different tenants. On the side of cloud service provider, this maximises the resource utilisation and profit since only one application instance is required to deploy in the cloud. On the cloud consumer side, each consumer feels that he/she is the only users	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	APIs). Lack of a proper interoperability can also limit flexibility to use various cloud services where each service provider proposes proprietary interfaces to access services. (iv) Application licensing.	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Data loss was minor though it could be very harmful. Developers should empower the application with proper countermeasures to deal with such behaviors though in some cases unpredictability can be out of control of either application owner or cloud provider.	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Lindner et. al. [S38] believe that cloud migration involves different interconnected cloud service providers and consumers that form a supply chain model. A service is provided at the start of the supply chain and a consumer at the end uses this	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	As an example in the context of cloud migration, according to (Louridas, 2010) there is a difference between the US and EU for addressing the ultimate to data protection in the cloud. That is, in the US, a cloud provider is responsible for completely data protection whilst in EU, the cloud consumer is final responsible to ensure if the cloud provider satisfies data protection requirements. As this concern can impact migration process, a migration approach, which is used for moving data tier of legacy application to	Ivon Miranda Santos

Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Planning in this methodology is defined as actions in order to resolve potential incompatibilities between legacy components and target cloud database solution without modifying the application business logic. Likewise, Pahl et. al. consider planning in terms of cloud service provider capabilities, addressing contract with partners, distribution of project team, capabilities of migration team (e.g. technology, skills, and tools), and defining metrics and milestones [S18]. In the process model of Legacy-to-Cloud Migration Horseshoe, proposed by [S21], authors incorporate the influence of cloud provider selection and migration type as main factors to develop a migration plan. Furthermore, defining a proper roll back plan, i.e. switching to the previous version of the	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Similarly, [S33] recommends defining Backward Availability for critical migration projects in the case new cloud application fails. 5.4.7 Cloud Service/Platform Selection Approaches can be assessed based on the extent to which they properly define activities to identify, evaluate, and select a set of cloud providers that might suit organization and application requirements. In justifying this criterion, Chauhan and Babar examined their suggested process model for moving an open source system to Amazon Web Service and Google App Engine	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	[S5] report a breakdown of activities involved in moving a .NET n-tier application to run on Windows Azure and highlight efforts required for deciding cloud providers is major. They underline the influences of selecting cloud platforms on the	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	If the selected cloud platform technology is highly similar to the legacy, less modification in the legacy is required. In general, from 43 reviewed approaches the following important factors were identified for investigation when conducting the activity cloud provider selection: variety of service models offered by provider, price model, the form of SLA, additional services such as backup, monitoring, auto-scaling, security mechanisms, implementation technologies which are supported by provider such as programming languages, development platforms, allowing access to internal operational logs, physical location of application data [S2], sustainability [S4], commitment durability with cloud provider, business objectives [S8], degree of automation, storage encryption mechanisms, storage format and exchange, developer SDKs [S9] and [S10], required configuration effort, deployment speed, consistent development experience [S17], and traffic bandwidth at the client network [S29]. Once a provider(s) is selected, a contract between the legacy application owner and the cloud service provider is signed. The application owner needs to specify the scope of expected service provisioning by cloud provider prior migrating application components to the infrastructure of a	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Andrikopoulos et al. [S35] numerate several factors are taken into account for component selection such as data privacy, expected workload profile, acceptable network latency and performance variability, availability zone of cloud providers, the affinity of components in the cloud, and the geographical location of cloud servers.	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	To take the advantage of dynamic deployment, one architectural requirement is to decouple application components so that they can interact in a transparent manner. Decoupling also enables independent elastic scaling of the components (i.e. dynamically adding/removing more instances of the same components), minimise time required for code refactoring and test in the case of changing cloud provider, handle a-synchronised communication, as well as simplify coping with the components failures.	Ivon Miranda Santos

Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	To support dynamic deployment and independent component scalability, components should be stateless and minimise storing contextual data. Moreover, the coexistence of multiple running instances of the same components in the cloud environment requires a new session management mechanisms in order to track tenant's behaviors and ensure their security when a number of instances is increased or decreased based on the server workload.	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Therefore, a certain level of integration and interoperability testing is required. Important tests that should be taken into account are Data Verification, Test Backup and Recovery Plan before they required [S23], Test Network Connectivity (connection between cloud services and local network), Test Connection Speed as there is network latency to receive a response from the cloud server located in different geographical areas [S33] [S40], test provider performance variability and test application latency due to the network performance variability	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	This data are used to detect deviations from SLA and runtime application adaptation and optimisation. Measuring can be fulfilled either by developing a new component which is integrated with the application and is responsible for this purpose or can be offered by cloud service provider [S1] [S4] [S22] [S23], [S28] [S33] [S40] [S43]. — Updating patches and periodical backup. During the application operation in the cloud, regular patch updated and database backup needs to be addressed either by application owner or by the	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Replication is performed to support high business continuity and minimal downtime by running several application instances on a variable number of cloud infrastructures. The partitioning and replication may entail extending the application for support of synchronisation between the components (local replicas and those hosted in the cloud), though if a cloud provider supports this, then the application can leverage it [S33]. — Terminating idle	Ivon Miranda Santos
Gholami2016-Cloud_migration_process—a_survey_evaluation_framew	CLOUD SERVICE PROVIDERS > Cloud provider	Business Model Framework (CBMF), Linthicum Cloud Computing Framework (LCCF), Oracle Consulting Cloud Computing Services Framework, IBM Framework for Cloud adoption (IFCA), BlueSky Cloud Framework for e-Learning, and Hybrid ITIL V3 Framework for Cloud. — Decision making frameworks aiding users to rank, evaluation, and selection cloud providers that fit legacy application requirements. — Studies in	Ivon Miranda Santos
Gourisaria2020-An_Extensive_Review_on_Cloud_Computing	CLOUD SERVICE PROVIDERS > Cloud provider	10.1 Security Issues Security issues are chiefly categorized into two broad categories, the ones faced by the service providers and the other by the clients who fall back on cloud computing for their business. In order to prevent leakage of information belonging to a client, service providers have fallen back on systems and careful monitoring to protect the	Ivon Miranda Santos
Hajjat2010-Cloudward_bound_Planning_for_beneficial_migration_of	CLOUD SERVICE PROVIDERS > Cloud provider	For instance, if traffic is not permitted from certain enterprise users to a server located in the cloud, it is desirable to ensure that the unauthorized traffic is filtered at the enterprise edge itself rather than filter it after it has traversed the wide-area link to the cloud. Finally, the problem is further complicated due to reassignment of IP addresses after mi-gration as is the practice of certain cloud providers today.	Ivon Miranda Santos
Hajjat2010-Cloudward_bound_Planning_for_beneficial_migration_of	CLOUD SERVICE PROVIDERS > Cloud provider	While we assume the benefits for migrating all servers in a class is the same, the model could be eas-ily extended to consider heterogeneity in benefits across servers in each class, which may arise for instance due to the the age of the hardware already in place in the enterprise. Estimating the benefits per server, Bc and Bs, is in general non-trivial, and is potentially dependent on the particular enterprise and choice of cloud provider. An infrastructure-as-a-service of-fering like EC2 [1], for instance, might not obviate the need for database adminstrators unlike a platform-	Ivon Miranda Santos

Hajjat2010-Cloudward_bound_Planning_for_beneficial_migration_of	CLOUD SERVICE PROVIDERS > Cloud provider	An edge-cut-set consists of a set of placement locations {l}, each specifying an interface and the direction of traf-fic (inbound or outbound) to which an ACL placed on that interface applies. In general, each cloud provider has its own infrastructure, which influences where ACLs can be placed in the CDC. For instance, some cloud providers may grant cloud users the ability to perform VM-level filtering [1], or offer proprietary techniques to specify ACLs for groups of VMs	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	With the promise of providing flexible and elastic comput-ing resources on demand, the cloud computing has been at-tracting enterprises and individuals to migrate workloads in the legacy environment to the public/private/hybrid clouds. Also, cloud customers want to migrate between cloud providers with different requirements such as cost, performance, and manage-ability. However the workload migration is often interpreted as an image migration or re-	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	Because the target environments are diversified and enterprises have a large num-ber of servers, the migration planning quickly becomes a in-tractable problem. Also, as the competition becomes stronger, cloud providers increasingly offer more diversified services and they differentiate their catalogs with more advanced service features [3, 4]. A deterrent for enterprise migration to the cloud is a lack of migration planning tools that can scrutinize the discovered on-premise data, provide comprehensive analytical information to reason about why the migration can help reduce opera-tional expenses and increase performance,	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	ENTERPRISE-SCALE MIGRATION Cloud transformation for an enterprise IT environment entails the processes that migrate an enterprise's data, appli-cations, and services from on-premise data centers to a cloud environment, or to multiple cloud environments respectively 978-3-901882-77-7 cc 2015 IFIP □□□	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	978-3-901882-77-7 cc 2015 IFIP □□□ &160))XOO33DSHUCmanaged by different cloud providers. A typical migration process starts with the discovery stage, followed by the analy-sis of the uncovered source environment and evaluation of its fitness to the target [5, 15].	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	As the target environment becomes more diversified, the complexity on deciding where to move rather than how to move renders migration analytics a harder problem. The pos-sible choices for target environments include container, (pub-lic/private) virtual machine, baremetal, POD (Performance Op-timized Data Center), datacenter, geo-location, cloud provider, service model. As shown in Figure 1 that illustrates	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	B. Target Catalogs As shown in Figure 1, cloud users can choose various aspects in clouds depending on the enterprise requirements and types of workloads. Cloud users often choose one or more cloud providers depending on the service model (IaaS, PaaS, SaaS), geo-locations, and data centers. Once these high-level attributes are determined, the next step is to use the migration analytics to	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	Eventually we map the source resources to the optimal target resources defined in the catalogs. Since cloud providers support different catalogs, we need to identify the details of those catalogs. Table II summarizes the example catalogs from IBM SoftLayer. We can also easily collect the supported catalogs from PaaS or SaaS, and also from other cloud providers if cloud users decide to use one of them. The catalogs are used as an input to the migration analytics when it seeks matched target resources from observed source	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	Performance items are measured for two weeks period. For target catalogs, we use one cloud provider, SoftLayer, in the experiments, but the same experiment can be easily performed to any other	Ivon Miranda Santos

Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	In the custom virtual environment using a baremetal server and own hypervisor, allocating maximum resources is allowed. However the cloud providers usually do not expose the maximum capacity, instead it standardizes the resources with limited sizes. Figure 7 illustrates the ratio of cloud-fitness (here called cloudability).	Ivon Miranda Santos
Hwang2015-Computing_resource_transformation__consolidation_and_	CLOUD SERVICE PROVIDERS > Cloud provider	Liu et al. [17] propose COPE (Cloud Orchestra-tion Policy Engine), a distributed platform that allows cloud providers to perform declarative automated cloud resource orchestration. In COPE, cloud providers specify system-wide constraints and goals using COPElog, a declarative policy language geared towards specifying distributed	Ivon Miranda Santos
Jambunathan2018-Architecture_decision_on_using_microservices_or	CLOUD SERVICE PROVIDERS > Cloud provider	Application hosting on Cloud is becoming more popular and becoming inevitable these days and organization are either forced to migrate the existing application onto cloud or developing cloud native application using services provided by service providers. In the process they are trying to re-architect, re-host, re-platform their application to the new platform or architecture and would like to exploit the features provided by the service providers and make it effective in the cloud environment. Application development in cloud becomes more modular, interoperable and distributive in nature and many new evolving technologies like docker[1] containers, microservices[2] and serverless[3] architecture	Ivon Miranda Santos
Jambunathan2018-Architecture_decision_on_using_microservices_or	CLOUD SERVICE PROVIDERS > Cloud provider	In addition, organization wants to reduce the cost and wanted to develop and host the application as and when they need it and avoid the cost of owning and running the server on their own. Cloud service provider provides options these days to host and run the application on demand and provide API / services to do so and make the application more event based and hence when they need it or when the event occurs, the application is getting triggered and hence wanted to make use of this on-demand approach to reduce the cost and operational overhead of managing the servers on their own. We would like to introduce each technology in details and discuss in this article on the merits and demerits of all the three emerging technologies – serverless computing, microservices and container and how	Ivon Miranda Santos
Jambunathan2018-Architecture_decision_on_using_microservices_or	CLOUD SERVICE PROVIDERS > Cloud provider	Platform-as-a-Service greatly simplifies deploying applications. It allows us to deploy the app and the cloud service provider worries about how to deploy the servers to run it. Most PaaS hosting options can even auto-scale the number of servers to handle workloads and save money	Ivon Miranda Santos
Jambunathan2018-Architecture_decision_on_using_microservices_or	CLOUD SERVICE PROVIDERS > Cloud provider	The units of integration with Serverless (Functions) are a lot smaller than with other architectures and therefore we rely on integration testing a lot more than we may do with other architectural styles. SERVERLESS OPTION WITH CLOUD SERVICE PROVIDERS With increased popularity of Serverless architecture, cloud service providers like Amazon web services (AWS) and Microsoft Azure provides support for serverless	Ivon Miranda Santos
Jambunathan2018-Architecture_decision_on_using_microservices_or	CLOUD SERVICE PROVIDERS > Cloud provider	There are many containers available but docker is the most accepted one and are open source, have its own ecosystem to manage. Like VM, container also has its own life cycle to manage and every cloud service provider, be it a public cloud like AWS, Azure, Google or private cloud like OpenStack, VMware supports Docker containers. For example – AWS has elastic container service (ECS)[4] and Azure provides	Ivon Miranda Santos
Jambunathan2018-Architecture_decision_on_using_microservices_or	CLOUD SERVICE PROVIDERS > Cloud provider	It also simplifies build and release process and support complete devops functionality. Every cloud service provider supports Microservices architecture and has its own API and services to support this development model and enable developers to build a truly distributed application. The relation between containers (Dockers) and microservices is that, it's isolated language neutral and distributive nature helps developers to easily containerise the application and deploy across.	Ivon Miranda Santos

Jamshidi2013-Cloud_migration_research_A_systematic_review	CLOUD SERVICE PROVIDERS > Cloud provider	The assumption for each of the approaches is that in its initial state, the software application is hosted on-premise in a noncloud environment, for example, on a local server, before the migration is applied to it. Therefore, migration between cloud providers, deployment models, and virtual resources known as live migration is outside the scope of this work. To date, there has not been a systematic literature review (SLR) of research on cloud migration, making it difficult to assess the maturity in general and identifying trends, research gaps, and future	Ivon Miranda Santos
Jamshidi2013-Cloud_migration_research_A_systematic_review	CLOUD SERVICE PROVIDERS > Cloud provider	According to Fig. 4, test, architecture recovery, and decision of cloud providers are the most common migration tasks and crosscutting tasks as well as architecture adapta-tion are the least popular tasks among the primary studies. In terms of automated support, for processes I and III, there is satisfactory evidence, but for process II and crosscutting concerns, the evidence amount is	Ivon Miranda Santos
Jamshidi2013-Cloud_migration_research_A_systematic_review	CLOUD SERVICE PROVIDERS > Cloud provider	Since the items related to the migration support theme are not related to experience reports, we do not consider them in Table 11. Decision support in migration processes covers tasks to facilitate decision making, such as the study of migration feasibility, deciding which subsys-tem to be migrated or which cloud provider to choose (see Table 10). Migration execution comprises tasks that enable the actual migration of a legacy	Ivon Miranda Santos
Jamshidi2013-Cloud_migration_research_A_systematic_review	CLOUD SERVICE PROVIDERS > Cloud provider	Thus, there is a need for systematic architectural support for adaptation purposes during cloud migration. As an example, the logical separation between the cloud service providers and the applications, the agreed contract between them is one of the distinguishing aspect of cloud applications that need to be supported by architecture description—see [34] as an initial attempt toward cloud application architectures. We believe that the notion of migration path as a sequence of transitional architectures and tools supporting the architect to select the best path	Ivon Miranda Santos
Jamshidi2015-Cloud_migration_patterns_A_multi-cloud_service_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Multi-cloud denotes the usage of multiple, independent clouds by a client or a service. A multi-cloud environment is capable of distributing work to resources deployed across multiple clouds [10]. A multi-cloud is different from federation where, a set of cloud providers voluntarily interconnect their infrastructures to	Ivon Miranda Santos
Jamshidi2015-Cloud_migration_patterns_A_multi-cloud_service_arc	CLOUD SERVICE PROVIDERS > Intracloud and federation	A multi-cloud is different from federation where, a set of cloud providers voluntarily interconnect their infrastructures to allow sharing of resources [10].	Ivon Miranda Santos
Jamshidi2015-Cloud_migration_patterns_A_multi-cloud_service_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Resource constraints limit scalability, Need to improve performance, Single point of failure, Reduce cost, Modernization Solution: Re-deploy on cloud environments, make use of elastic resources, multiple cloud deployment for failover	Ivon Miranda Santos
Jamshidi2015-Cloud_migration_patterns_A_multi-cloud_service_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Challenges: On-premise application is modernized in isolation; Modernization is performed primarily for technical reasons, Com-ponent architecture is only determined bottom-up may need to be re-evaluated because of multi-cloud environment. Migration Pattern MP3:	Ivon Miranda Santos
Jamshidi2015-Cloud_migration_patterns_A_multi-cloud_service_arc	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Definition: A re-architected application is deployed partially on multiple cloud environments and enables the application to contin-ue to function using secondary deployment when there is a failure with the primary platform. Problem:	Ivon Miranda Santos
Jamshidi2015-Cloud_migration_patterns_A_multi-cloud_service_arc	CLOUD SERVICE PROVIDERS > Cloud provider	Step 7. Value-added services from the cloud such as caching can maximize perfor-mance when retrieving data or can cache output, session state and profile information MP3 was selected to accommodate these environmental services of the cloud	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	Circumstances which require public clouds to be used jointly with on-premises resources. Cloud-based applications must be resilient to the loss of a single data center or cloud provider. Current cloud migration methods are coarse-grained, making detailed planning difficult.	Ivon Miranda Santos

Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The patterns define architectural changes in the application re-engineering and deployment setting, through which an application is gradually modernized and deployed in a multi-cloud environment. In this context, a migration plan is defined as a composition of selected patterns for addressing specific architectural situations and	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	task. These factors relate to the characteristics of the main entities in the migration decision – which are the interested organization, the on-premise legacy architecture, and the possible cloud provider platforms. We use profiles to characterize those entities – which is a form of a	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	These examples can guide the identification of potential organizational constraints: Divergences between emergency handling policies established within the organization and those implemented by the cloud provider; Loss of governance and/or control over existing IT	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	Define cloud platform profiles Profiles of one or more cloud platforms (including multi-cloud scenarios) should also be created. Each candidate cloud platform and its provider can be captured in terms of whether they satisfy the organisational and technical constraints. Service models.	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	Organizational constraints. Examples are organizational constraints where the evaluation depends on specific knowledge of the application or candidate cloud provider, for example, if the organization is legally required to keep application data within a certain region.	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	Availability constraints. Availability of resources in the cloud is related to the SLA guarantees offered by the cloud provider. They can also be affected by communication constraints.	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	Thus, any application constraint problems identified should be addressed, for example, by changing the application profile. Moreover, the cloud provider might also need to be changed if platform conflicts occur, in which case a revised cloud platform profile should be considered. 3.5.	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Intracloud and federation	A multi-cloud is different from a federation where a set of cloud providers voluntarily interconnect their infrastructures to allow sharing of resources among each other [25].	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	In a multi-cloud configuration perspective, parts of the application can be deployed on PaaS, IaaS or both [15, 24], see Figure 4 for an example. The wide range of cloud providers currently available and their platforms likely to host the application makes the selection a proper architectural configuration a difficult task. To match these requirements and dimensions, we identified 15	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	Technical Constraints. Cloud-based applications must be resilient to the loss of a single data center or cloud provider. To address the challenges identified here and allow to guide the architecture migration process, we define an orthogonal variability model, as we	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	enable users to choose their preferences of accessibility options – an access model for cloud operators and users; capture cloud providers' visible options for deployment – a platform model for cloud operators and users. Three individual variability models, that have their origin in the description and process model and its profiles, can be identified, see Figure 1.	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Multi-cloud denotes the usage of multiple, independent clouds by a client or a service. A multi-cloud environment is capable of distributing work to resources deployed across multiple clouds [29]. A multi-cloud is different from a cloud federation – for the latter a set of cloud providers voluntarily interconnect their services to allow	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	A multi-cloud environment is capable of distributing work to resources deployed across multiple clouds [29]. A multi-cloud is different from a cloud federation – for the latter a set of cloud providers voluntarily interconnect their services to allow sharing of resources [29]. Hybrid deployment is a special case of multi-cloud where an application is deployed in both on-premise as	Ivon Miranda Santos

Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Intracloud and federation	A multi-cloud is different from a cloud federation – for the latter a set of cloud providers voluntarily interconnect their services to allow sharing of	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Cloud provider	Value-added services from the cloud such as caching can maximize performance when retrieving data or can cache output, session state and profile information. MP3 was selected to accommodate these environmental services of the cloud provider. Note that, as quality of the cloud platform deployment is the key concern here, the platform	Ivon Miranda Santos
Jamshidi2017-Pattern-based_multicloud_architecture_migration	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	1182 P. JAMSHIDI, C. PAHL AND N. C. MENDONÇA often multi-cloud environments. Our implicit assumptions here included the possibility to	Ivon Miranda Santos
Kratzke2017-Understanding_cloud-native_applications_after_10_ye	CLOUD SERVICE PROVIDERS > Cloud provider	Introduction The birthday of the cloud can be dated into the year 2006 – the first launch of a general purpose public cloud service (Simple Storage Service, S3 at 13th March 20061) by the currently most prominent public cloud service provider Amazon Web Services (AWS). Therefore, this study has not considered any papers dated before 2006.	Ivon Miranda Santos
Kratzke2017-Understanding_cloud-native_applications_after_10_ye	CLOUD SERVICE PROVIDERS > Cloud provider	Meanwhile other providers and further services followed. All these cloud providers and their services forming nowadays our understanding of the term cloud computing. Al-though terms like public/private/hybrid cloud computing and acronyms like IaaS (Infrastructure as a Service), PaaS (Platform as a Service) or SaaS (Software as a Service) are frequently used, these terms are	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	We start with a background on service composition in single clouds. Then, we present the multicloud taxonomy, and we study how service composition was tackled by researchers in multicloud environments. Finally, we iden-tify the challenges and the requirements of multicloud service composition, as well as the future	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The collected works from the literature do not exceed 21 approaches. In this survey, we study the service composition in the cloud, with a main focus on multicloud environments. The contributions of this work are as follows: • We present the background of service composition in traditional single clouds, and we present a taxonomy of the multicloud environments. • We provide a classification and a comparison of existing multicloud service composition (MCSC) approaches. • We discuss the major issues related to the service composition problem in the context of multicloud environments.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Section 4 presents the background on single-cloud service composition. Section 5 provides a classification of multicloud environments. J Softw Evol Proc.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Security and privacy, as well as other related issues in themulticloud setting, are briefly presented in Sections 8 and 9, respectively. Finally, we summarize the challenges and requirements for an effective service reuse in the multicloud environment, and we conclude the paper with future directions.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	It is also used while developing a software. The latter is hosted by the PaaS providers after its development.17 The SaaS offers the ability to access and use applications whose cloud provider is unknown by the consumer. Software applications are delivered as Web services thanks to this software deployment and distribution model.17 Besides these 3 shapes of Cloud services, other service models have emerged.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	MCSC, multicloud service composition FIGURE 3 Multicloud service composition: composition aspects and environments, considered service models, multicloud issues, and challenges. IaaS, infrastructureas a service; SaaS, software as	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	4. We discussed the most related issues to the service composition problem in multicloud environments.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	How MCSC requirements and future directions were identified according to the papers' evaluation steps? Before conducting our research, we examined the articles that tackle the service composition problem onto a multicloud environment. As shown in Table 1, only 21 multicloud approaches were published from 2012 to May 2017 and were selected from prestigious journals and conferences in different publishers, including Elsevier, IEEE, Springer, and ACM. The result of this effort is a number of papers that will provide different views on the service composition issues in multicloud environments.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Low resource settings	In many cases, no single service can satisfy a cloud consumer's requirements, which often are expressed as a combination of various types of virtualized resources (eg, looking for a SaaS service that will be executed in a specific platform on a large-size VM). In such situation, cloud service composition allows organizing various software applications and virtualized resources (eg, storage, platforms, and mashup applications) into a set of interacting services to construct cloud services that meet specific quality criteria. Considered as a complex and NP-hard problem, cloud service composition is an optimization problem introduced for the first time in Zeng et al6 and Kofler et al.21 Service composition is a method used by researchers in order to decrease the cost and the risk resulting from producing new applications.13 It is used in order to select the appropriate services, according to the user preferences, which are efficient in building new functionally rich services.22 Before that, service composition has been used for the Web services,23-25 in order to provide trustworthy, ubiquitous, and personalized	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud-computing service composition is defined by Jula et al1 as the mechanism of choosing; from the services available in the cloud environment, those able to be combined together in order to obtain a service composition whose criteria are as agreed in the service level agreement (SLA). A high number of the existing approaches are realized in the context of single cloud, in which only 1 cloud provider exists. In the following subsections, we will present the possible cloud service composition modalities and dimensions, as well as a recap on the existing service composition approaches	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Quality-of-service attributes for PaaS services include availability, accessibility, security, and reliability, whereas those specific to SaaS include security, reliability, performance, interoperability, scalability, and availability.27 Quality-of-service attributes are generally expressed in the user request, depending on the demanded cloud service model. The user request is the set of requirements expected by the consumer, to be satisfied using a composite service from the multicloud environment. The user requirements can be divided into 2	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	This is why companies started to construct complex services from several clouds, by perplexing the way that business process fragments (BPFs) can collaborate through different clouds, which makes it possible to delay the discovery of the complete structure of business processes by malicious providers. 5 THE MULTICLOUD ENVIRONMENT The cloud computing paradigm, as it was defined by the National Institute of Standards and Technology for the first time, consists in offering services deployed by 1 provider (eg, Nirvanix, Google Apps,	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Therefore, only 1 availability zone hosts the services offered by either public or private clouds. The hybrid cloud could be also considered as a single-cloud environment if both the used public and private clouds are served by the same provider. In contrast, the multicloud is a distributed	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The hybrid cloud could be also considered as a single-cloud environment if both the used public and private clouds are served by the same provider. In contrast, the multicloud is a distributed environment composed of several clouds, in which it is possible	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	However, it is in some cases safely to adopt a multicloud solution. In organizations with various requirements, it will be better to use different cloud providers. This migration offers more autonomy while selecting services, as it gives the customer the possibility of choosing from the set of candidate offers the most performant one, at	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Furthermore, using several clouds is also successful in avoiding downtime and data waste, enhancing the enterprise performance and eschewing vendor lock-in.22 The classification of the multiple cloud environments (MCEs) differs from one article to another. Therefore, different cloud taxonomies have	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Intracloud and federation	• Crossclouds, in such environment, a series of steps consisting of matchmaking, resource discovery, and authentication, is followed by a federation of several cloud suppliers in order to offer/use resources.22	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	LAHMAR AND MEZNI 7 of 24 FIGURE 5 Multicloud environment FIGURE 6 Intercloud classification	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Intracloud and federation	• Intercloud,the clouds used in this approach are assembled into groups according to certain criteria such as trust, identity, naming, time areas, and addressing.22 Figure 6 shows the intercloud classification, as it is presented in Grozev and Buyya.52 According to Kurdi et al,49 multicloud and cloud	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	But Grozev and Buyya52 recognize the difference between these 2 words: A federation is the voluntary interconnection between miscellaneous cloud providers in order to share the available resources. This is the reason behind naming the cloud federations “volunteer federation.”	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Intracloud and federation	A federation is the voluntary interconnection between miscellaneous cloud providers in order to share the available resources.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_su	CLOUD SERVICE PROVIDERS > Intracloud and federation	This is the reason behind naming the cloud federations “volunteer federation.”	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	However, in a multicloud, the available clouds are independent and their resources are managed by the clients, so the interconnection between providers is not voluntary. The service composition process in the multicloud environment consists of finding a set of corresponding services across 2 or more clouds, in order to produce a composed service able to satisfy the user's requirements. Among the advantages of the MCSC is eschewing vendor lock-in that	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Composing services from several clouds is also efficient in decreasing the amount of data wasted during the composition and optimizing the fault tolerance.22 According to the composition architecture (see Figure 7) proposed in Kurdi et al,49 the user starts by entering his request in the interface. The cloud combiner is responsible for handling the needed requirements and extracting the optimal cloud combination from themulticloud environment. Then, the cloud composer receives the combination from the cloud combiner and chooses the adequate service composition with minimum	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	FIGURE 7 Multicloud service composition process. MCE, multiple cloud environment 6.1 Composition using simple services	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	6.1 Composition using simple services Given the emergence of a high number of new service providers (eg, Windows Azure Platform, Amazon S3, and EC2), the offered QoS, the pricing models, and the existing security policies of cloud services vary from one provider to another.61 Therefore, proposing methods that combine several services from multiple locations becomes a necessity. In the following classification, the	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	For example, in metaheuristic and agent-based approaches, the collective intelligence is adopted to converge, in a very reduced time, to the optimal region of clouds that host the best services. The combinatorial-based approaches consist in selecting, from the multicloud environment, the clouds offering the highest number of services in order to find the best services in a short execu-tion time. Whereas in the clustering-based approaches, grouping the most pertinent services or clouds according to their common features allows keeping only those able to satisfy the users' requirements, that is to say, reducing the search space to a specific cluster and, thereafter,	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Whereas in the second algorithm, artificial ants try to find the optimal path in the graph according to the pheromone amount and the heuristic information on the edges. Zhang et al65 used the GA while composing services onto a geo-distributed multicloud environment. For better results, the used GA uses an improved version of crossover and mutation	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	This approach suffers from the ignorance of service locations in cloud data centers, and, in some cases, the optimal solution is not found. The massive amount of data exchanged, while compositing a high number of services from the multicloud environment, is the reason behind the increase of the energy consumption. In Baker et al,69 the pivotal objective is reducing the number of composed services and their providers in order to meet the user requirements of energy	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	A multiagent system is a distributed system composed of several agents in interaction with one another in order to cooperate, coordinate, and negotiate to achieve a specific goal.70 In cloud environment, the cloud participants and resources can be modeled or represented by agents that interact in order to reach an effective service composition. Each agent has its own acquaintance list, in order to deal with missing information about the cloud providers and the multicloud10 of 24 LAHMAR AND MEZNI environment in general.26 Agents can also negotiate with cloud providers on behalf of users to reach an agreement on the offered QoS and select the optimal service composition that comes from multiple clouds. The first agent-based approach that deals with cloud service composition was presented in Gutierrez-Garcia and Sim.26 It considers differ-ent	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Mezni and Sellami50 presented an MCSC approach in order to fulfill the user requests by combining services from several clouds. Reducing the number of involved clouds, the number of service providers and also the intercloud communication cost are the main objectives defined by the authors in this approach. The multicloud objects	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	So, it is unknown what service belongs to what fragment. From the above approaches, we could notice that just 1 approach19 has considered the problem of reusing BPFs in the multicloud environment. So till this moment, this problem is not as much	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	• Used technique: presents the technique used for the composition (eg, particle swarm optimization, FCA, ACO, clustering, and MapReduce). • Context: indicates whether the composition is realized in a multicloud environment, a cross-cloud environment, an intercloud, etc. • Dimension: indicates whether the service composition is realized in a vertical or horizontal	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Therefore, the recent approaches tend to select services from several clouds, such as intercloud in Zhang et al56 and crosscloud in Dou et al53 (see Figure 9). For most researchers, the main objective behind composing services in a multicloud environment was ensuring a high QoS, reliability, flexibility, etc. Despite the advantages of the multicloud environment, we could remark from the above related works that most of the approaches that reuse process fragments are not proposed for reusing SPFs from the cloud environment, such as Yang et al58 and Zemni et al.59,60 Only 1 approach proposed in Nacer et al19 considers reusing fragments from the existing business processes in the multicloud environment. It is clear from the comparative table that the Web service model is the most used by researchers, due to its heterogeneous nature that helps this type of service in overcoming platforms and languages diversity problems (it uses standard	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Before sending them to the cloud, the consumers are also responsible for adding privacy enforcement structures to the data to protect it from disclosure.76 The security is also considered as the biggest barrier, especially in the federated and multicloud environment. For example, when dealing with SaaS applications, the major security concern is often about the data protection and location, the security policies of the cloud providers, etc. Given the cloud environment complexity and dynamicity, the traditional security solutions are no longer effective in dealing with themulticloud security issues. From today's security solutions, we could mention the secure cloud storage, which is a cloud service responsible for protecting the data existing in some cloud models or other platforms. This solution gives the consumers access to control their sensitive information on the cloud, to always ensure their privacy.77 Another security solution is named the intelligent protection, which is also a cloud security service developed to ensure the security of servers and applications existing in the cloud infrastructures.77 Protecting the private and critical information from loss or theft, facing control and privacy issues, guaranteeing data integrity and confidentiality, etc are some of the challenges involved while dealing with cloud services.78 The issues surrounding	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	The security is also considered as the biggest barrier, especially in the federated and multicloud environment. For example, when dealing with SaaS applications, the major security concern is often about the data protection and location, the security policies of the cloud providers, etc. Given the cloud environment complexity and dynamicity, the traditional security solutions are no longer effective	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	This solution gives the consumers access to control their sensitive information on the cloud, to always ensure their privacy.77 Another security solution is named the intelligent protection, which is also a cloud security service developed to ensure the security of servers and applications existing in the cloud infrastructures.77 Protecting the private and critical information from loss or theft, facing control and privacy issues, guaranteeing data integrity and confidentiality, etc are some of the challenges involved while dealing with cloud services.78 The issues surrounding security are serious in 1 single cloud as in a multicloud environment. But what makes the multicloud much better is that the trust, reliability, and security capabilities are distributed among (and ensured by) several cloud providers. • Data integrity. While transmitting the stored data between the user and the cloud provider, it could suffer from damage. So in 1 single cloud, if the	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Therefore, responding to the user requirements will be impossible. However, in case where the data are stored on multiple clouds and one of them is affected by the attacks, we could simply move toward another cloud provider. • Data intrusion. Cloud providers are responsible of protecting the user's important information from external and internal attacks. So in case where any user information is stolen from a single-cloud environment, it will be lost forever. However, in the case where we are composing ser-vices from a multicloud environment, the user information is still safe, as it is protected by other providers or perplexed to delay its discovery between several involved clouds. • Data availability.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	So in case where any user information is stolen from a single-cloud environment, it will be lost forever. However, in the case where we are composing ser-vices from a multicloud environment, the user information is still safe, as it is protected by other providers or perplexed to delay its discovery between several involved clouds. • Data availability.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	So data-related failures could be compensated by another cloud.79 9 OTHER ISSUES IN MULTICLOUD ENVIRONMENT In addition to service composition, tremendous other issues in multicloud environment have been addressed by researchers, such as intercloud SLA enactment,80 dynamic service selection,73 crosscloud monitoring,81 service deployment,19 and adaptive service management.8218 of 24 LAHMAR AND MEZNI 9.1 Data service composition Given the rapid increase in the amount of generated data and the increasing ability of complex computational analysis, data-intensive services com-position has emerged, to offer complex services that are able to process the huge volume of highly dynamic data, so that to respond to consumers complicated requirements.83 This problem has been addressed in several approaches.83-86 The first appeared challenge, while dealing with this problem in a multicloud settings, is the huge	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	9.2 Service selection Other works have addressed the service selection issue in multicloud environments73 and deal with the changes that may occur after selecting the cloud services. To solve such problems and to fulfill the users requirements, the authors provide a model and a strategy for the dynamic selection of cloud services.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	9.3 SLA issues The advantages of using services from multiple clouds and the heterogeneity of the QoS requirements are the reasons behind investigating the SLA in a multicloud environment, in order to maximize the user's profit. SLA interoperability and issues	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	This description is realized using ontology in order to deal with the problem of matching several services from multiple clouds, as it is the case in the DNA workflow. Because of the increase and heterogeneity of users' requirements that need more complex services and because of the overhead costs in the multicloud environment, the SaaS providers may encounter difficulties while exploiting the IaaSs. This is why Farokhi et al89 proposed a hierarchical and SLA-based service selection approach,	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	This description is realized using ontology in order to deal with the problem of matching several services from multiple clouds, as it is the case in the DNA workflow. Because of the increase and heterogeneity of users' requirements that need more complex services and because of the overhead costs in the multicloud environment, the SaaS providers may encounter difficulties while exploiting the IaaSs. This is why Farokhi et al89 proposed a hierarchical and SLA-based service selection approach,	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Thereafter, to realize the service selection, 2 steps are adopted by the author. In the first phase, new SLAs, named the “InterCloud-SLAs,” are constructed and contain the provider's requirements regarding the QoS. Those requirements are divided into functional ones called sub-SLAs and	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	know-how preservation but also makes its system vulnerable. The restrictions of a single-cloud service deployment have resulted the emergence of the multicloud as a deployment environment. For example, Nacer et al19 considered that scattering the business activities and deploying them in	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The applied reconfiguration is dedicated to replace the affected services without influencing the execution of the whole composition. Ismail and Cardellini74 proposed an architectural model that deals with the heterogeneity and dynamicity of cross-layer and multicloud environments. The presented model adopts a self-adaptation solution in a decentralized manner, in order to ensure a better quality for the deployed applications.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	9.5 Service monitoring The complexity of cloud infrastructure translates into more effort needed for the monitoring and adaptation of services and resources in such environment. The greater scalability and larger size of multicloud environments, compared to traditional cloud or Web service hosting infrastructures, involve more complex monitoring and adaptation systems, which have therefore to be more scalable, robust, and fast. The applications existing in the multicloud platforms often require monitoring mechanisms to supply information about real-time QoS. Quality-of-service monitoring is important	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	This is achieved by using the Markov decision process. 10 MULTICLOUD ENVIRONMENT CHALLENGES The multicloud environment is becoming more and more popular, due to the variety of the appeared service models and its ability to deal with issues in the traditional cloud environment. Despite that, tremendous problems appeared in this colossal environment and need to be addressed such as	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	lock-in, data integrity, etc; 2. Access: such as authentication, authorization, and access control in each cloud; 3. the differentinfrastructures and platformsin the multicloud environment, including the storage and the security aspects in each data center.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Providers offers, different VMs are offered according to their storage capacity, CPU, etc; 3. Cloud providers policiesto consolidate and place VMs; 4. Hardware capacity, which is associated to the physical hosts/nodes.94	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Dynamicity: The multicloud environment is highly dynamic and may encounter frequent changes: 1. in the user requirements.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	• the reduction of the number of involved clouds and, thereafter, the reduction of the execution time and inter-cloud communication cost. These needs appeared following the necessity of combining services from multicloud, crosscloud, intercloud, etc environments, where the choice of the appropriate services is multiple. Given that the communication between providers in the cloud environments mentioned above is costly and time consuming, minimizing the number of the used clouds is a basic objective during the composition process.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	These needs appeared following the necessity of combining services from multicloud, crosscloud, intercloud, etc environments, where the choice of the appropriate services is multiple. Given that the communication between providers in the cloud environments mentioned above is costly and time consuming, minimizing the number of the used clouds is a basic objective during the composition process. • the accuracy and the protection of the private data during the composition, given the uncertainty and dynamicity of the cloud environment.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	• the satisfaction of the user's requirements by selecting services that meet at best what is mentioned in the SLA. Investigating the SLA in the cloud computing facilitates the selection of the appropriated services from the multiple clouds environment. It offers an acceptable degree of service quality, which allows to avoid composing useless services.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	So the mentioned response time must be achieved and the resulted services must be reliable. We should notice that several commercial and open source tools have been developed by leading cloud providers to allow composing and manag-ing cloud services. However, most of them deal with only particular service models in a traditional cloud	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	However, most of them deal with only particular service models in a traditional cloud environment. The proliferation of multicloud environments has raised the need for effective multicloud management tools, to allow enterprises spread their services across multiple clouds.Mul-ticloud tools are expected to accelerate services deployment and scaling and to automate monitoring, governance, and configuration tasks.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	The proliferation of multicloud environments has raised the need for effective multicloud management tools, to allow enterprises spread their services across multiple clouds.M	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	They also can be seen as an abstraction layer that keeps the multicloud complexity under control by hiding the heterogeneity of clouds and providing the needed flexibility to users. That is why leading cloud providers, such as IBM, Amazon, and Microsoft, started to develop multicloud commercial plat-forms and tools. For example, IBM has announced its cloud automation manager, which offers a dashboard that allows companies to manage their	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	That is why leading cloud providers, such as IBM, Amazon, and Microsoft, started to develop multicloud commercial plat-forms and tools. For example, IBM has announced its cloud automation manager, which offers a dashboard that allows companies to manage their multicloud environments based on applications' requirements. Cloud Data Encryption is another	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	That is why leading cloud providers, such as IBM, Amazon, and Microsoft, started to develop multicloud commercial plat-forms and tools.	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Open source tools were also proposed to deal with multicloud management issues, taking as example, BOSH,* a multicloud scalable release engineering tool, and Cloud Foundry,† which is a tool for the deployment and scaling of applications in multicloud PaaS.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	It is clear that the available commercial and open source tools for multicloud service integration are at an early stage. In fact, there is no tool that considers various service deployment and delivery models (eg, SaaS and IaaS), as most of them focus on PaaS platforms. In addition, the standard-ization efforts on cloud service description and semantics, as well as on interoperability between heterogeneous clouds are not fully exploited in the existing solutions. Moreover, existing multicloud tools do not offer planning facilities or mechanisms for automated MCSC.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	As a core component in multicloud tools, service composition engines must take into account different service models and cover semantic aspects of consumers and services, in order to personalize the cloud services compositions according to consumers needs and preferences. Multicloud ser-vice composition tools should also define environment constraints and security concerns when dealing with different dimensions and modalities of cloud service composition. Such tools should also manage the changes in the multicloud environment (eg, emergence of a new resources or services and service unavailability). 12 FUTURE DIRECTIONS From the above discussions and the identified issues, it is clear that the multicloud environment is an untrusted and highly dynamic cross-platform, which is also considered as a big distributed	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	As a core component in multicloud tools, service composition engines must take into account different service models and cover semantic aspects of consumers and services, in order to personalize the cloud services compositions according to	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Multicloud ser-vice composition tools should also define environment constraints and security concerns when dealing with different dimensions and modalities of	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Such tools should also manage the changes in the multicloud environment (eg, emergence of a new resources or services and service unavailability).	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	A challenging problem in a distributed, dynamic, and untrusted cloud environment is to consider security constraints in service composition.53 In fact, there are several security issues when composing services with uncertain availability and security constraints. Existing secure service composition mechanisms only focus on SLA availability rates and assume a fully trusted cloud provider, which is not always true.97 To address these issues in a multicloud environment, it is important to provide a service composition by combining the safest services coming from the most trusted cloud combination, ie, clouds that comply at best with user's preferences and policies and offer an appropriate level of safety. Also, with the growing need to offer business processes as Cloud services, also called BPaaS,98 it becomes a challenge for consumers	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	A challenging problem in a distributed, dynamic, and untrusted cloud environment is to consider security constraints in service composition.53 In fact, there are several security issues when composing services with uncertain availability and security constraints. Existing secure service composition mechanisms only focus on SLA availability rates and assume a fully trusted cloud provider, which is not always true.97 To address these issues in a multicloud environment, it is important to provide a service composition by combining the safest services coming from the most trusted cloud combination, ie, clouds that comply at best with user's preferences and policies and offer an appropriate level of safety. Also, with the growing need to offer business processes as Cloud services, also called BPaaS,98 it becomes a challenge for consumers	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_su	CLOUD SERVICE PROVIDERS > Intracloud and federation	For that, an alternative way is to combine the strengths of multicloud and cloud federation.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	13 CONCLUSION In this survey, we have studied the service composition problem in multicloud environments.We started by defining the topic of service composition in the cloud computing, and we discussed the	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Finally, we enumerated the major requirements that need to be considered during multicloud composition, and we provided the future directions in the multicloud context. With respect to the findings in this survey, future research efforts should be directed in order to offer facilities to consumers and providers in mul-ticloud environments. For example, it is of paramount importance to design composition engines that take into account the heterogeneous nature of cloud services and the characteristics of the	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Finally, we enumerated the major requirements that need to be considered during multicloud composition, and we provided the future directions in the multicloud context. With respect to the findings in this survey, future research efforts should be directed in order to offer facilities to consumers and providers in mul-ticloud environments. For example, it is of paramount importance to design composition engines that take into account the heterogeneous nature of cloud services and the characteristics of the	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Also, the multicloud field lacks tools and datasets for evaluating MCSCs.	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Cloud provider	Hence, it is important to provide datasets with different sizes and standard problems. Such datasets must include various data such as QoS for each service model, a great number of services, and providers and clouds related data. Aiming to prepare a complete environment for MCSC, our future work involves (1) the collection and the study of benchmarking and evalua-tion tools, in order to see their adequacy to the multicloud setting; (2) the implementation of several MCSC scenarios, while considering various kinds of cloud services, various composition modalities and dimensions, etc; and (3) the selection of a set of well-known MCSC approaches	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Aiming to prepare a complete environment for MCSC, our future work involves (1) the collection and the study of benchmarking and evalua-tion tools, in order to see their adequacy to the multicloud setting; (2) the implementation of several MCSC scenarios, while considering various kinds of cloud services, various composition modalities and dimensions, etc; and (3) the selection of a set of well-known MCSC approaches	Ivon Miranda Santos
Lahmar2018-Multicloud_service_composition_A_su	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Such steps will help to effectively design and implement tools for multicloud environments.	Ivon Miranda Santos

Lahmar2018-Multicloud_service_composition_A_survey_of_current_a	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	71. Bastia A, Parhi M, Pattanayak BK, Patra MR. Service composition using efficient multi-agents in cloud computing environment. In:	Ivon Miranda Santos
Lichtenthaler2019-Requirements_for_a_model-driven_cloud-native_	CLOUD SERVICE PROVIDERS > Cloud provider	The REST version covers only the backend functionality and in the first iteration we took the frontend as it was. We used OpenFaaS3 as a platform, because of its open-source nature and because it enabled local development without depending on a cloud provider. We could have also used, for example,	Ivon Miranda Santos
Lichtenthaler2019-Requirements_for_a_model-driven_cloud-native_	CLOUD SERVICE PROVIDERS > Cloud provider	Therefore, also another important characteristic is added: It describes whether a component is self-managed or managed, e.g. con-sumed as a service from a cloud provider. The migration project of Iosifescu-Enescu et al. [6] illustrates this by shift-ing functionality from self-managed components to services of the cloud provider. As an example they name the shift from individual	Ivon Miranda Santos
Lichtenthaler2019-Requirements_for_a_model-driven_cloud-native_	CLOUD SERVICE PROVIDERS > Cloud provider	In the PSM, a concrete decision has to be made on where the system should be deployed, e.g., at which cloud provider or in a private cloud. There are various options for deploying applications in the evolving cloud services landscape and	Ivon Miranda Santos
Lichtenthaler2019-Requirements_for_a_model-driven_cloud-native_	CLOUD SERVICE PROVIDERS > Cloud provider	The information in the PIM is rather abstract, for example consid-ering the scalability requirements of a component. The PSM should therefore include the available technological choices from a cloud provider, as also mentioned by Menychtas et al. [16], to enable a fitting transformation to	Ivon Miranda Santos
Mahmood2020-Erp_issues_and_challenges_a_research_synthesis	CLOUD SERVICE PROVIDERS > Cloud provider	The next section reflects detailed analysis along with a discussion about the issues and challenges specifically related to cloud ERP (Table VI). 5.2 Cloud enterprise resource planning: issues and challenges Software as a service (SaaS) is one of the services offered by cloud providers. Cloud ERP system solutions offered by cloud providers fall in the SaaS category of cloud services. Although cloud ERP addressed different challenges of	Ivon Miranda Santos
Mahmood2020-Erp_issues_and_challenges_a_resear	CLOUD SERVICE PROVIDERS > Cloud provider	, 2004). Which are made between cloud service providers and enterprise? According to Rong et al.	Ivon Miranda Santos
Mahmood2020-Erp_issues_and_challenges_a_research_synthesis	CLOUD SERVICE PROVIDERS > Cloud provider	new technologies. Cloud is still a new phenomenon; therefore, cloud ERP service providers should educate the customer to promote awareness about cloud ERP. This research review supports validates the past research findings (AlBar and Hoque, 2019) that cloud awareness	Ivon Miranda Santos
Maniah2022-A_systematic_literature_review_Risk_analysis_in_clou	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud Computing is a service that provides network storage space and computer resources using an internet connection as a medium of access. Cloud Service Providers (CSP) offer attractive services, making more and more companies want to migrate to the cloud. Sometimes the migration process to cloud computing faces problems or even failures, and	Ivon Miranda Santos
Maniah2022-A_systematic_literature_review_Risk_analysis_in_clou	CLOUD SERVICE PROVIDERS > Cloud provider	But behind the benefits obtained by cloud service users, there are also problems or risks that arise, as illustrated when there is a cloud outage by Amazon, because data storage is centralized in the cloud, this can paralyze the company's business that depends on that data (Gupta and Gupta, 2014). Attacks on the cloud computing environment can cause data loss as well as financial losses for cloud service provi-ders as well as cloud servic@@e users (T.K and B, 2016). This is a form of risk that appears in the cloud environment, namely the risk of threats to data	Ivon Miranda Santos
Maniah2022-A_systematic_literature_review_Risk_analysis_in_clou	CLOUD SERVICE PROVIDERS > Cloud provider	Why migrate to the cloud? Cloud migration can save costs because cloud service providers already provide infrastructure so that it can reduce the provision of their own infrastructure (Ren et al., 2012).	Ivon Miranda Santos

Maniah2022-A_systematic_literature_review_Risk_analysis_in_clou	CLOUD SERVICE PROVIDERS > Cloud provider	Several other reasons for companies migrating to the cloud are: (1) because cloud comput-ing services have scalability, which means that they can meet the needs of information technology resources according to company needs; (2) because the cloud provider has provided settings for both hardware configuration and software updates or server set-tings and others, so that companies as cloud service users are more focused on developing better innovative products; (3) because the cloud provider has a data center that provides fast and efficient computing services, so this will have an effect on high performance in the cloud compared to the data center owned by the company. Based on data from cisco.com, it is estimated that in 2020 cloud	Ivon Miranda Santos
Maniah2022-A_systematic_literature_review_Risk_analysis_in_clou	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	However, by migrating to the cloud, users cannot directly control the system that manages their data and applications, because data users and cloud servers are not in the same domain. Especially for public cloud service users who imple-ment a Shared Multi - tenant Environment. Multitenancy security and privacy are important challenges for cloud users, because multitenancy allows multiple	Ivon Miranda Santos
Maniah2022-A_systematic_literature_review_Risk_analysis_in_clou	CLOUD SERVICE PROVIDERS > Cloud provider	, 2017). Other efforts in risk mitigation in the cloud environment, such as: the Cloud-Trust system, which is a system used for security systems that are used to measure the level of confidentiality and integrity offered by CCS or cloud service providers (CSP) (Sharma et al., 2018), as well as the model security-as-a-service which is a model for security services in the cloud (Jouini and Ben	Ivon Miranda Santos
Maniah2022-A_systematic_literature_review_Risk_analysis_in_clou	CLOUD SERVICE PROVIDERS > Cloud provider	The identification of risk types and risk components in cloud migration as well as the opportunities for their emergence, which have been described in the results of this study, are a researcher's contribution to cloud service users. Attractive service offerings by Cloud Service Providers (CSPs), more and more companies want to migrate to the cloud, but companies as users of cloud services are also faced with risks. Information security risk, which is the type of risk	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The motivation for this work is the necessity to select an appropriate cloud storage provider offering for the migration of applications with less cost and high performance. However, the selection of a suitable cloud storage provider is a complex problem that entails various technical and organizational aspects. In this research, a dynamic Decision Support System (DSS) for selection of an appropriate cloud storage provider is proposed. A web-based application is	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The proposed mechanism has been optimized in a way that enables the system to address static database issues for which a user might not acquire the best solution. It focuses on comparing and ranking cloud storage providers by using two modules: scraping and parsing. The evaluation of the proposed system is carried out with appropriate test cases and compared with existing	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Major services are Software as a Service (SAAS), Platform as a Service (PAAS), and Infrastructure as a Service (IAAS). In SAAS cloud computing, the provider ensures availability of both software and internet service. The market for SAAS is end-	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	How to meet these demands with the least amount of resources is a challenge that system developers and stakeholders have to face. As the cloud business increases, many organizations are joining the market as cloud storage and service providers. The majority of providers offer similar services with different pricing since data	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	How to meet these demands with the least amount of resources is a challenge that system developers and stakeholders have to face. As the cloud business increases, many organizations are joining the market as cloud storage and service providers. The majority of providers offer similar services with different pricing since data	Ivon Miranda Santos

Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Organizations are interested in migrating their legacy local data storage to cloud-based storage to get maximum benefits with less cost, sharing, consistency and scalability. The number of cloud storage providers has increased due to rapid changes in technology. However, the selection of the right cloud storage for an organization is not an easy task due to the involvement of many diverse	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	iii. The AHP technique, most trusted for decision-making problems, is implemented for comparing and ranking of cloud storage providers. The paper is organized as follows.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The parameters used in this research were elastic computing, storage, and network services. Three case studies were performed to identify the best cloud storage provider according to the requirements of an organization. Zenuni et al. [14] has identified the criteria for the selection of cloud storage providers and analyzed several cloud storage providers on the identified parameters. Their selected key parameters were availability, security, storage, file size, API, SLA, pricing, mobile support, and platform. The impact of small and large files was also observed on eight (8) cloud storage providers. They demonstrated	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	It is designed like a DSS tool that provides assessment of cloud services in accordance with KPIs w.r.t user requests. Users provide the essential and non-essential requirements, and the system gives a list of cloud service providers. A knowledge-based DSS (KBDSS) [9] is introduced to support organizations and respond to their queries, which helps in ideally shifting to the cloud	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	After gathering requirements from users, it uses its SMI service calculator and ranking of vendor storage services to provide a sorted list of providers to the customer. SLA management is also part of this module, which keeps track of SLAs between customers and cloud service providers. The Broker system takes input in the form of requirements from the customer, and	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The SMICloud-Service Catalogue module is used for storing the offers provided by different cloud vendors. In the development of this framework, the main problem faced was calculation of KPIs associated with different cloud service providers. In the next segment, a QoS framework is developed for IAAS service providers based on	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	This framework introduces three-layered engineering (client, server, software), which consolidates the front end for client communications. A learning base with data assembled from cloud providers on their services offers a back end that con-tains the vendor choice and cost-figuring rationale. A cloud service provider's information base is enhanced by adding more offerings that include information on different attributes like cost, number of CPU cores, storage size, synchronization, sharing, etc. Besides gather-ing cloud provider information (e.g., offers), it will	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The next module is a cost calculator that takes input from both offer matching and knowledge provider modules, and calculates the cost of each matched offer. The PKB is the brain of MDSS where all cloud provider data reside. A model of this framework (shown in Figure 3) was executed as an internet application written in C# and	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Their project is based on the methods and model-driven engineering (MDE) tools. Only two cloud providers are showing offers (Google and Amazon), and have some common offerings with varying costs. In almost all the frameworks as discussed above, none of them is a complete system that covers all aspects of a	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Their project is based on the methods and model-driven engineering (MDE) tools. Only two cloud providers are showing offers (Google and Amazon), and have some common offerings with varying costs. In almost all the	Ivon Miranda Santos

Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The following limitations have been found after the study and analysis of the previous research work: i. After getting a user's requirements, current DSSs show the results from a static database, so there is always a chance of missing the latest offers from cloud stor-age providers. ii.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Proposed Decision Support System Cloud computing adaptation has been growing in recent years due to its striking busi-ness framework established on the provision of unseen cloud computing resources, such as software, networks, servers, bandwidth, and data repositories. Cloud storage providers charge clients on the basis of hour, month, and year. A cloud computing environment provides a flexible subscription service for any application, which can	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Additionally, developers in organizations need to learn all imaginable technical boundaries that might interrupt cloud acceptance by the organization. Another issue that restricts or confuses an organization wanting to migrate to a cloud environment is the availability of a large number of cloud storage providers and their offers with marginal differences in cost. In this section, we discuss the design methodology of the proposed DSS, which starts by defining and	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	All essential parameters are identified, which is part of the process when applications shift to the cloud. The main issue after identification of requirements is that there are a lot of cloud storage providers. Sometimes, a very small change in the specifica-tions can result in very	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The user has to choose a sensible value that decreases the legacy system's expenses with a lower cost and higher performance. The main task of the suggested DSS is to rank cloud storage providers on the basis of services by considering two aspects: cost and performance. Performance is an array of multiple parameters.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The important function is a comparison of providers and rank-ings that works based on the user's selected parameters. A database is created to store information about multiple cloud providers. Different operations are performed on the basis of this data. Two steps are followed when fetching data from cloud providers. First, data are fetched from the required vendor site with	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	A generalized conceptual module of the proposed system is shown in Figure 5. It is used to rank and compare cloud storage providers' data, and generally, its major responsibility is to calculate parameters matching as well as cost. Communication of data between the system handler and data provider module is performed	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Cost parameters are based on monthly or yearly [26] service fees. Parameter values are fetched from the website of the cloud provider, subsequently cost is calculated and shown to users. A cloud storage provider's data collection is extracted by the cloud data scraper or extractor module, which has two sub-modules: Cloud Data Extractor and Cloud Data Parser. The extractor module is used to get the desired data from the cloud provider's website. It will decide which	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The market requests all-encompassing web scraping arrangements that incorporate distributed storage and simplicity to manufacture interoperable APIs. The data extractor fetches the specific data against the selected parameters of the cloud providers from their websites and sends it to DSS database.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	So, at that stage, the system pauses and inserts raw data so it can be refined with good presentational and normalized positions. Data coming from different cloud provider websites are taken through this scraper module. The step-by-step process is explained in the flow chart shown	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Flow Chart of Cloud Data Extractor. Figure 7 shows the step-by-step procedure to extract data from cloud providers. The list of vendors' links in the form of an array is passed to the data extraction procedure where the system checks all links and their availability.	Ivon Miranda Santos

Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Flow Chart of Cloud Data Extractor. Figure 7 shows the step-by-step procedure to extract data from cloud providers. The list of vendors' links in the form of an array is passed to the data extraction procedure where the system checks all links and their availability.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	3.2.2. Cloud Offer Comparison The module shown in Figure 9 has two parts: first compares data that are requested from the user, and second compares the cloud providers. If there are two cloud storage providers, C1 and C2, with parameters P1 and P2, respectively, then P1 will be compared with P2. In cases, when the user selects a requirement, a comparison (or matching)	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	3.2.3. Cloud Service Provider Ranking The ranking module is a very important part of the DSS [30,31] that gives two options to the user (rank by cost or performance) because some organizations have a limited budget and want to stay within their budget. On the other hand, some organizations need better performance, and budget is not a big issue, so they prefer a system with a better	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The performance ranking calculation is performed on the right side, while the steps for cost ranking are on the left side. The data store is accessed from both sides of the flowchart, which starts with selecting the type of ranking and ends with a list of ranked cloud storage providers.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The user role is defined in the use-case diagram as shown in Figure 4 (for example, check ranking or comparison). In the cloud service comparison, users can select parameters to obtain a list of cloud providers. Then, users can choose any cloud provider according to their needs by selecting parameters like number of CPU cores, amount of storage, and availability of synchronization and/or file sharing. The system displays the results against the user input on the user interface. For ranking, the user can select the ranking type based on the cloud storage provider list and ranked on the basis of user selection type.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	One of the main concerns of the system is to get dynamic contents from cloud vendor websites. In that case, data can be collected from the listed cloud storage providers all at one time and use it for system computations. In Figure 11, the cloud data scraper and cloud data parser modules on the left side are added to make the DDS dynamic.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The web scraper is written for data extraction where large amounts of data or information are collected across the internet. A simple HTML Dom is used to fetch data and extract values from cloud storage provider's web pages by using the function file_get_html (URL). Figure 12 indicates input on the left side, process in the middle, and output on the right side. The purpose of the scraper is to fetch cloud storage provider data and save it in raw form in a MySQL database. The	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Figure 13 illustrates raw data, shown on the left side, extracted from the database by Node.js, and then the parsing mechanism starts. Cloud service provider ranking is one of the most important parts of the proposed decision-making system. Ranking is basically a priority list of cloud providers, and is generated by calculating comparative ranking values for different cloud services based on performance and cost. Because	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Figure 13 illustrates raw data, shown on the left side, extracted from the database by Node.js, and then the parsing mechanism starts. Cloud service provider ranking is one of the most important parts of the proposed decision-making system. Ranking is basically a priority list of cloud providers, and is generated by calculating comparative ranking values for different cloud services based on performance and cost. Because multiple attributes are involved, ranking cannot be	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	One of the important tasks in the AHP technique is assigning weights to attributes, which are called relative importance values (RIV). After a study of previous research and its analysis, nine values for cost and nine values for performance attributes were taken for ranking cloud storage providers. Table 3 shows the RIV for each option.	Ivon Miranda Santos

Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	8 Synchronization × X Twenty cloud storage providers are selected to test the proposed DSS: Sync.com, Just-Cloud, Dropbox, Tresorit, LiveDrive, PCloud, hubiC, Jumpshare, iCloud Drive, MediaFire, OpenDrive, SugarSync, ADrive, Mega, Google Drive, SafeCopy, OneDrive, Amazon Drive, Atlantic.net,	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	A structured technique AHP is used to calculate ranking w.r.t the costs of different cloud services. The goal is to rank cloud provider services on monthly and yearly cost criteria. In the second layer, there are alternatives described as “alternatives values for the above criteria”. The third layer is for the cloud providers that need to be ranked. Ranking is calculated based on the	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	8 Synchronization Twenty cloud storage providers are selected to test the proposed DSS: Sync.com, JustCloud, Dropbox, Tresorit, LiveDrive, PCloud, hubiC, Jumpshare, iCloud Drive, Me-diaFire, OpenDrive, SugarSync, ADrive, Mega, Google Drive, SafeCopy, OneDrive,	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	A structured technique AHP is used to calculate ranking w.r.t the costs of different cloud services. The goal is to rank cloud provider services on monthly and yearly cost criteria. In the second layer, there are alternatives described as “alternatives values for the above criteria.” The third layer is for the cloud providers that need to be ranked. Ranking is calculated based on the	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	In Figure 15, the criteria are shown on the second layer while alternatives are shown on the third layer, and the cloud service vendors are shown on the bottom layer. We have selected the “number of CPU cores” as a parameter for the selection of cloud provider as it affects the retrieval of data as well as processing.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	User Services Selection is developed especially for non-technical users. This comparison page is used to collect requirements with a menu as shown in Figure 18, and users can see a list of cloud providers generated based on the requirements.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	5.1. Ranking Validation by Using AHP In the first experiment, the cloud storage providers ranking is calculated manually by using AHP and comparing the results with the proposed system. Weights from 1 to 8 are assigned to the parameters according to their importance, ‘1’ represents the minimum whereas ‘8’ indicates the	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	OS Linux Windows Mac Priority Linux 0.49 0.18 0.48 61.1% Windows 0.25 0.09 0.03 13.8% Mac 0.10 0.27 0.10 17.5% Most of the cloud providers offer a synchronization option so their clients can sync devices with the cloud storage. The major benefit of the	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	This table will be used in all further calculations. The cloud storage provider’s comparison provides the values and their ranges (as shown in Table 5). Ranking of cloud service providers will be calculated on the basis of these parameter values and their corresponding weights from Table 25.	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The vendor that has the largest value is the best vendor with respect to performance. Figure 19 shows a clear picture of the performance ranking of cloud providers, where Google and IBM have almost the same rank because they provide maximum computing resources. Cloud storage providers are shown on the X-axis and their rankings, calculated by a structured technique, on the Y-axis. Cloud service providers like SafeCopy and iCloudDrive have low rankings due to lower	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The vendor that has the largest value is the best vendor with respect to performance. Figure 19 shows a clear picture of the performance ranking of cloud providers, where Google and IBM have almost the same rank because they provide maximum computing resources. Cloud storage providers are shown on the X-axis and their rankings, calculated by a structured technique, on the Y-axis. Cloud service providers like SafeCopy and iCloudDrive have low rankings due to lower	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system	CLOUD SERVICE PROVIDERS > Cloud provider	Table 25. Cloud Storage Providers’ Performance-based Rankings.	Ivon Miranda Santos

Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The reason behind the differences is the use of Round() function in PHP. However, the overall rankings of the cloud providers are the same. The comparison graph as shown in Figure 20 is generated based on values gener-ated with manual AHP calculations, as presented in the above sections, and from values generated by the	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The baseline for this calculation is a one-core CPU with 500 GB of storage. Weights of all parameters from the cloud storage providers are calculated as shown in Table 27. The Ranking and the Cost columns are added in order to perform	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The baseline for this calculation is a one-core CPU with 500 GB of storage. Weights of all parameters from the cloud storage providers are calculated as shown in Table 27. The Ranking and the Cost columns are added in order to perform	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	The aim of this exercise is to identify those cloud vendors who provide more benefits at less cost. From the graph, we can easily identify Google as the cloud provider with top benefits and less cost. It also shows that iCloud gives fewer benefits, compared to the others, but its cost–benefit ratio	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	Comparison with Existing Models Finally, functionality of the proposed system is compared with previous systems. Most of the previous studies are conceptual, and still their implementation is not possible because they were introduced between 2000 and 2015, and at that time, cloud storage providers had different offerings as well as technology. Another flaw in	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	However, in the case of cloud computing, one can access hardware, information and services from anywhere at any time. The number of cloud storage providers has increased with the enhancement of the cloud. Many cloud providers offer the same features with little or no alteration but a huge difference in cost. Therefore, selection of a cloud storage provider is a very important task; otherwise, organizations have to pay a huge amount of money. This research has compared twenty (20) different cloud storage providers on the basis of their features. We proposed a web-based dynamic DSS for ranking and comparing	Ivon Miranda Santos
Mateen2021-A_dynamic_decision_support_system_for_selection_of_c	CLOUD SERVICE PROVIDERS > Cloud provider	A dynamic database module is added that gives quick updated results. The AHP technique is adopted for comparing and ranking cloud storage providers. The following issues will be investigated further in	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	SPECIAL ISSUE PAPER A multicriteria optimization model for cloud service provider selection in multicloud environments Amany M. Mohamed1 Hisham M. Abdelsalam2	Ivon Miranda Santos

Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Email: amanymagdymohamed@gmail.com Summary Multicloud computing is a strategy that helps customers to reduce reliance on any single cloud provider (known as the vendor lock-in problem). The value of such strategy increases with proper selection of qualified service providers. In this paper, a constrained multicriteria multicloud provider selection mathemat-ical model is proposed. Three metaheuristics algorithms (simulated annealing [SA], genetic algorithm [GA], and particle swarm optimization algorithm [PSO]) were implemented to solve the model, and their performance was studied and compared using a hypothetical case study. For the sake of comparison, Taguchi's robust design method was used to select the algorithms' parameters values, an initial feasible solution was generated using analytic hierarchy process (AHP)—as the most used method to solve the cloud provider selection problem in the literature, all three algorithms used that solution and, in order to avoid AHP limitations, another initial solution was generated randomly and used by the three algorithm in a second set of performance experiments. Results showed that SA, GA, PSO improved the AHP solution by 53.75%, 60.41%, and 60.02%, respectively, SA and PSO are robust because of reaching the same best solution in spite of the initial solution. KEYWORDS	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Infrastructure as a Service (IaaS), Software as a Service, and Platform as a Service (PaaS).1 This paper focuses on IaaS in which customers can use available services (virtual machines [VMs], networking, storage, etc.) in terms of service level agreement; a contract between customers and cloud service providers where cloud service providers (the latter) guarantee a satisfactory level of quality of service (QoS) requirements.2 Cloud service provider selection is one of the most significant challenges for cloud customers.3,4 Due to the growing number of cloud providers, cloud market is becoming more and more competitive. Prices and performance levels of the similar offered services are varied, and, consequently, selecting an appropriate provider that can fulfill	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	2 MOHAMED and ABDELSALAM Although service cost is considered as a main criterion used to compare different cloud providers,5-13 customers had to consider many other criteria due to the increasing number of providers and the diversity of services offerings. Conse-quently, some research papers, from customer perspective, tried to answer the question of what are the most important criteria for cloud provider selection?12,14,15 But, measuring the identified criteria was not a simple task because of lack of standard to various providers.16 Therefore, the Cloud Service Measurement Index Consortium has developed service measurement index (SMI),17 a standard measurement framework which helps decision-makers to compare cloud services from multiple providers. SMI includes seven major characteristics with three or more attributes/key performance indicators (KPIs) in each characteristic.17 Based	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Research papers applied weighted methods to solve the problem such as analytic hierarchy process (AHP),6,7,11-13,18 ranked voting method,16,19 and technique of order preference by similarity to ideal solution (TOPSIS).20 The previous research papers proposed frameworks and models to tackle the provider selection problem by ranking different providers based on different criteria in order to select a single cloud provider to satisfy customer's requirements. So, the main shortcoming in these researches is forcing the customer to accept the	Ivon Miranda Santos

Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	That in addition to overlooking the customer's acceptable level of each criterion. Although using the data center of a single provider to host cloud applications is easy and provides obvious advantages, it arises a number of challenges. A large data center consumes a lot of energy to keep it operational, besides the risk of sin-gle point failures resulting from centralized cloud data centers. Additionally, applications with sensitive or personal data may have to be stored in different territory because of data centers may be geographically distant from its customers.21,22 In contrast to using resources from a single cloud provider, applications now aim to use cloud infrastructure to maximum advantage by using different resources from multiple providers.21 Different applications/systems are suited to different platforms. For example, an enterprise may favor Amazon or Google to analyze big data, but to run Microsoft-centric applications it may prefer Azure. Multicloud is a strategy that uses services and resources from multi-ple cloud provider,23 therefore the application can be run on different IaaS platforms based on those applications' unique needs. So, it is a strategy that helps customers to avoid vendor lock-in problem and improve QoS or minimize costs. Building a multicloud solutions poses a number of challenges.22 One of these challenges is that each cloud provider has different application programming interfaces (APIs) that makes the provisioning, deployment, monitoring and manage-	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Consequently, the third step provides PaaS frameworks such as Cloudify,31 CloudFoundry,32 and Scalr.33 Some of these frameworks base on so-called DevOps tools that automate the provisioning, deployment, and management of multicloud systems. Cloud provider selection plays a significant role in increasing multicloud value. Despite of multiclouds challenges, its usage is increasing and, thus, it became the focus of recent research papers.21 References 34-37 focused on VMs and pro-posed models/schemes for VMs placement across multiple cloud providers. While References 38-40	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Consequently, the third step provides PaaS frameworks such as Cloudify,31 CloudFoundry,32 and Scalr.33 Some of these frameworks base on so-called DevOps tools that automate the provisioning, deployment, and management of	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	While References 38-40 proposed multicloud storage models in order to secure customer's data. Authors in References 41-43 proposed different models to utilize the concept of multicloud for solving the energy-saving problem with the dynamic networking environment. Pervious published research work shares two	Ivon Miranda Santos

Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	(a) focusing only on one IaaS service and (b) considering cost as the main criterion and ignoring the other criteria. The gap in the literature was this research motivation to propose a general model for selecting providers in multicloud environment considering any number of infrastructure services based on different criteria in addition to considering customer's acceptable level for each criterion. Therefore, in this paper, the cloud provider selection problem is formulated as a constrained multicriteria multicloud provider selection problem. The most important contributions of this paper are as follows: • proposing a general model for selecting cloud providers in a multicloud environment considering any number of IaaS services;MOHAMED and ABDELSALAM 3 • formulating the proposed model based on multicriteria that includes cloud services evaluation's criteria and cloud providers evaluation's criteria; • considering the customer's acceptable level of each criterion; and • proposing three metaheuristic algorithms for solving the multicriteria multicloud provider selection problem. The multicriteria multicloud provider selection problem can be addressed using either a static or a dynamic approach. The static approach is appropriate for situations where the number of required IaaS services and the set of parameters that defined each service are constant (fixed number of VMs, fixed usage pattern of storage,	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	(a) focusing only on one IaaS service and (b) considering cost as the main criterion and ignoring the other criteria. The gap in the literature was this research motivation to propose a general model for selecting providers in multicloud environment considering any number of infrastructure services based on different criteria in addition to considering customer's acceptable level for each criterion. Therefore, in this paper, the cloud provider selection problem is formulated as a	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The most important contributions of this paper are as follows: • proposing a general model for selecting cloud providers in a multicloud environment considering any number of IaaS services;MOHAMED and ABDELSALAM 3 • formulating the proposed model based on multicriteria that includes cloud services evaluation's criteria and cloud providers evaluation's criteria; • considering the customer's acceptable level of each criterion; and • proposing three metaheuristic algorithms for solving the multicriteria multicloud provider	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Conse-quently, to solve it three metaheuristic algorithms were used and compared; Simulated annealing (SA), genetic algorithm (GA), and particle swarm optimization (PSO). The proposed multicloud provider selection model is compared to the sin-gle cloud provider selection model based on cost criterion. The proposed model minimized the cost by 25% when it is compared to the single	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Finally, conclusion and future work are given in Section 5. 2 MULTICLOUD PROVIDER SELECTION PROBLEM 2.1 Problem description The cloud provider selection model has three major stakeholders: customer, cloud broker, and cloud providers. In the provider selection process, cloud broker plays the main role because it acts as an intermediary between the customer and providers in order to satisfy customer's requirements. As shown in Figure 1, a customer	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	i | = Ai. Besides, a set of independent cloud service providers represented by P = ∪M j=1{pj}, where pj is an individual cloud service provider, and |P| = M. Each provider offers different infrastructure service types represented by S(P) j = ∪Kj	Ivon Miranda Santos

Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	(a) the deployment model is public cloud; (b) the service model is IaaS; (c) the pricing model is pay-as-you-go; and (d) each required service is rented from only one cloud service provider. 2.2 Problem formulation	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	(15) Suitability measure is customer focused and needs to be performed at the initial selection of the cloud provider. It is defined as the degree to which a customer's requirements are met by a Cloud provider. Thus, Suitij can be defined as:	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Objective function (5) is to maximize accountability. Accountability contains attributes used to measure the properties related to cloud service provider organization. These properties may be independent of the service being provided.	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	(23) Reference44 proposed an agent to select cloud service provider based on the RFV. RFV is calculated based on two variables:	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	(24) Equation (6) ensures that each required service is rented from only one cloud provider. In Equation (7), the total cost cannot be larger than the client	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The last constraint ensures that Xij is binary variable. 2.2.4 Data gathering in multicloud environments The quality of candidate solution made by the presented model is heavily dependent on the	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	2.2.4 Data gathering in multicloud environments The quality of candidate solution made by the presented model is heavily dependent on the quality of data used for evaluation of cloud providers. However, collecting the data from providers to be able to compare them and their ser-	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	It may be implemented as a stand-alone cloud computing utility or integrated into computing system utility. It is based on configuring the multicloud monitor in a cloud consumer computer to retrieve performance data from the provider multicloud monitors that configured in cloud computing environments. In the presented model, cloud broker acts as an intermediary between the customer/consumer and providers, so instead of configuring multicloud provider monitor in a cloud consumer computer, it can be configured in cloud broker computer to be able to collect the parameters' data that needed to evaluate different criteria. 3 SOLUTION ALGORITHMS Multicloud provider selection problem is proved to be NP-complete problem based on the similarity between it and the multi-item vendor selection (MIVS) problem that discussed in Reference.51 MIVS is a special type of procurement problem; it is the problem of procuring a number of different items from different vendors, with no interdependencies. MIVS is formulated as an	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	It may be implemented as a stand-alone cloud computing utility or integrated into computing system utility. It is based on configuring the multicloud monitor in a cloud consumer computer to retrieve performance data from the provider multicloud monitors that configured in cloud computing environments. In the presented model, cloud broker acts as an intermediary between the customer/consumer and providers, so instead of configuring multicloud provider monitor in a cloud consumer computer, it can be configured in cloud broker computer to be able to collect the parameters' data that needed to	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	A solution is represented as a vector consisting of two rows as shown in Figure 4. The first row represents the ID of the required services by the client, whereas the second row represents the cloud service providers ID. For example, the	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	(R) 3 will be rented from cloud providers 5, 12, and 20, respectively.10 MOHAMED and ABDELSALAM FIGURE 5 Pseudo-code of genetic algorithm FIGURE 6 Genetic algorithm solution	Ivon Miranda Santos

Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	FIGURE 8 Particle swarm optimization algorithm population representation randomly; for each required service, a random cloud provider is selected. However, to apply discrete PSO, the gen-erated population is	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Consequently, the population is represented by a group of matri-ces. Each matrix represents one particle (solution) with row represent the cloud providers and columns represent-ing the required services as shown in Figure 8. The cells assume	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	4 EXPERIMENTS AND PERFORMANCE ANALYSIS A hypothetical case study was generated to test the performance of the three algorithms by scanning the most popu-lar cloud providers and collecting the needed information. In order to	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Based on the selected services, a case study of eight client's requirements is generated. Besides, data of 60 providers was generated randomly by using the absolute minimum and absolute maximum of the scanned cloud providers. This section is dedicated to answer two main	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	(a) how much the cost is improved when using the multi-cloud selection model instead of single cloud selection model? and (2) what is robust solution algorithm for solving the proposed model? In order to answer the first question, the proposed multicloud provider selection model is compared to the single cloud provider selection model based on cost criterion. The proposed model minimized the cost by 25% when it is compared to the single	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	In the first phase, the parameters value of each algorithm were determined using Taguchi's method. In the second phase, AHP method was used to generate a candidate solution; from the literature, AHP was the most used method to tackle the selection problem of cloud providers. So, this motivated us to use the AHP candidate solution as an initial solution for the proposed	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	This representation is used to generate the initial solution. In this study, AHP is exploited to generate the initial group of cloud providers in order to satisfy user require-ments. But using AHP method, only one provider can be chosen, so for each requirement AHP is applied to select the candidate provider and it was applied through the	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	availability, reliability, transparency, and install-ability. The last level consists of the available cloud providers.MOHAMED and ABDELSALAM 15 FIGURE 9 Main effects plot 2.	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	It noticed that although the quality of solutions was improved, GA is still has better properties that SA and PSO. In the presented problem, generating an initial solution using AHP method will be very difficult when number of requirements and number of cloud providers increases. So, in order to overcome this problem, the performance of the algorithms with a random initial solution was	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	5 CONCLUSION This paper considered the constrained multicriteria multicloud provider selection problem. The problem was formulated as an integer programming model and three metaheuristic algorithms (SA, GA, and PSO) were proposed and	Ivon Miranda Santos
Mohamed2020-A_multicriteria_optimization_model_for_cloud_servic	CLOUD SERVICE PROVIDERS > Cloud provider	Cost evaluation in the presented model is limited to pay-as-you-go pricing model. However, cloud providers offer ser-vices at different prices using various pricing schemes. So, the future plan is formulating the presented model considering	Ivon Miranda Santos
Naik2021-Performance_evaluation_of_distributed_systems_in_multi	CLOUD SERVICE PROVIDERS > Cloud provider	Abstract—The design of distributed systems in multiple clouds have been gaining popularity due to various benefits of the multi-cloud infrastructure such as minimizing vendor lock-in, data loss and downtime. Nonetheless, this multi-cloud infrastructure also poses several challenges such as compatibility, interoperability, complex provisioning and configuration due to the variation in technologies and services of each cloud provider. Consequently, it is a tedious task to	Ivon Miranda Santos

Naik2021-Performance_evaluation_of_distributed_systems_in_multi	CLOUD SERVICE PROVIDERS > Cloud provider	Distributed systems can be made more effective if they are designed in multiple clouds by leveraging several benefits of the multi-cloud in-frastructure such as minimizing vendor lock-in, data loss and downtime [3], [4]. Nonetheless, this multi-cloud infrastructure also poses several challenges such as compatibility, interop-erability, complex provisioning and configuration due to the variation in technologies and services of each cloud provider [5]. Inevitably, it increases the complexity of design process of distributed	Ivon Miranda Santos
Naik2021-Performance_evaluation_of_distributed_systems_in_multi	CLOUD SERVICE PROVIDERS > Cloud provider	This section presents the simulated development of the previously described distributed system using Docker Swarm. This simulation is carried out in VirtualBox, where five docker machines are created; however, this VirtualBox design can be replicated with any preferred cloud provider to	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Amongst many problems being dis-cussed are: the lack of standard interfaces and open APIs [13], the lack of open standards for VM format [14] and service deployment interfaces [15], as well as lack of open formats for data interchange. These issues result in difficulties in integration between services obtained from different cloud providers as well as between cloud resources and internal legacy systems [16]. Conse-quently, this renders the interoperability and portability of data and	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	The emergent difficulty is a direct result of the current differences between individual cloud vendors offerings based on non-compatible underlying technologies and proprietary standards. In essence, cloud providers often propose their own solutions and proprietary interfaces for access to resources and services.	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	RDOI 10.1186/s13677-016-0054-zservice interfaces is a crucial problem since most of the current resources bind the customer to stick with one cloud technology due to high cost in porting the applica-tions and data to a different provider's interface. The heterogeneity in cloud computing is simply the existence of differentiated hardware, architectures, infrastructure, and technology used by cloud providers. Many cloud vendors provide services based on custom-built pol-icies, infrastructure, platforms, and APIs that make the	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	In other words a partially adopted standard would represent a poor solution. Es-sentially, this explicit lack of standards to support port-ability and interoperability among cloud providers stifles the market competition and locks customers to a single cloud provider [21]. To expatiate further, potential diffi-culties (by primarily technological means) in achieving interoperability and portability lead to lock-in – result-ing in customer dependency on the services of a single cloud computing provider [22]. From a legal stance, the dependency can be aggravated by the abusive conduct of a cloud computing provider within the meaning of Art-icle 102 TFEU (Treaty on the Functioning of the Euro-pean Union) [18], where other providers are excluded from competing from the customers of the initial cloud provider. In such situations, limitations to interoperabil-ity and portability could be seen as an abuse by a domin-	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Such practices dis-tort competition and harm consumers by depriving them of better prices, greater choices and innovation. Hence, the competition law has the role of ensuring competition is maintained and enforced in the market by regulating anti-competitive conduct by cloud providers. To this end, it can be concluded that cloud interoperability (and data portability) constraints are potential results of anti-competitive	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Vendor lock-in The vendor lock-in problem in cloud computing is the situation where customers are dependent (i.e. locked-in) on a single cloud provider technology implementation and cannot easily move in the future to a different vendor without substantial costs, legal constraints, or technical incompatibilities [23]. To substantiate further from the lenses of a software developer, the lock-in situ-ation is evident in that applications developed for	Ivon Miranda Santos

Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Amazon EC2, Microsoft Azure), cannot easily be migrated to other cloud plat-forms and users become vulnerable to any changes made by their providers [24]. Actually, the lock-in issue arises when a company, for instance, decides to change cloud providers (or perhaps integrate services from different providers), but is unable to move applications or data across different cloud services because the semantics of resources and services of cloud providers do not match with each other. This heterogeneity of cloud semantics [25] and cloud Application Program Interfaces (APIs) creates technical incompatibility which in	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	from the view point of the business to retain the flexibil-ity to change providers according to business concerns or even keep in-house some of the components that are less mission-critical due to security related risks. Inter-operability and portability among cloud providers can avoid the problem of vendor lock-in. It is the way to-ward a more competitive market for cloud providers and customers.	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	1) “How to avoid being locked-in to a single cloud provider? 2) How easy and secure is it to deploy existing cloud artefacts (e.g. software applications, databases, data, virtual servers etc.)	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	For these reasons, it becomes not only critical to consider security and privacy concerns but also related issues such as integration, portability, and interoperability between the software on-premise and in the cloud [35], should be taking into account. Therefore, organisations must be aware of appropriate standards and protocols used by cloud providers to support data/ application movability. Moreover, the ease of moving data across (i.e. portability) cloud providers’ platform mandates data to be in a compatible format [34], and in-cludes the need to securely delete the old storage [36]. In other words, the ability to move data/application about is of crucial importance, as much as the effort in-volved in actually moving –	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	making buying decisions in the cloud adoption process. This indicates that the role of IT manager in most organi-sations is still considered paramount as opposed to prem-ise that the advent of cloud computing will make IT management obsolete – that is, some of the existing IT management roles will be moved to cloud	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	6 shows the barriers identified by the participants. Respondents identified systems and data security risks, loss of control and over dependence on a single cloud provider (35.1 %) as core existing barriers to future cloud implementation. To confer from this result, the security is still a major con-cern for UK businesses in implementing cloud	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Moreover, the find-ings tie in with a recent study published by [41], of which (57 %) participants identified “the biggest chal-lenge in managing data security and privacy is compli-ance”. However, regarding systems and data security risks (63.1 %), cloud service providers can demonstrate their compliance with, and adherence to, industry-accepted standards for data security and integrity. In es-sence, this will show transparency in practice and cap-ability, and also assist the establishment of trust for organisations to implement/deploy their	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	The results in Fig. 8, highlights that besides the risks of data breach and cyber-attack, or failure to meet agreed service levels, UK businesses are also concerned about having corpor-ate data locked-in to a single cloud provider. These con-cerns affect the wider business functions where an enterprise is using cloud to perform essential	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Overall, the results indicate that these challenges closely relate to interoperability and data portability issues prevalent in the cloud environment. Moreover further results show that a significant majority (76.6 %) of participants were unsure of relevant (existing or emerging) standards to support interoperability across clouds and portability of data from one cloud provider to another.	Ivon Miranda Santos

Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	11, when asked to identify best practices to minimize lock-in risks in cloud migration, most business respondents identified the following as top mitigation strategies: (a) making well-informed decisions before selecting vendors and/or signing cloud contracts (66.4 %); (b) the need for an open environment for con-tinuous competition between providers in the cloud ser-vice market (52.3 %); (c) use of standard software components with industry-proven interfaces (39.3 %). Equally, in	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Moreover, this section presents strategic approaches for mitigating the risks and challenges of lock-in in cloud migration. Awareness of the commonalities among cloud providers To refer back to the first research question of interest to business adopters stated in section 1.1. UK business de-cision makers are rightly concerned about the risks of being locked into a single cloud service provider and the implications of such a risk including not having a clear exit strategy. There is a need for these organisations to understand what the exit strategy looks like, even if it is unlikely that they will exit in the near future –	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	connection, one possible strategy will require decision-makers to possess a comprehensive understanding of the heterogeneity that exist between cloud semantics and the cloud interfaces. This often requires an awareness of the commonalities (i.e. complexities and dependencies) among services offered by cloud providers and standards used. By clearly understanding this, organisations will realise how	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	6 indicate a general lack of understanding and awareness of lock-in problem in the cloud. The low re-sponse gained from participants who identified over de-pendence on a single cloud provider (35.1 %) and difficulty to move data back in-house or across to a dif-ferent cloud provider (28.8 %) platform illustrates the unawareness of practitioners on the potential effect of cloud lock-in problem. To infer from this result, it ap-pears the risk of dependency is a more significant barrier	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	lock-in will become more of an issue as the cloud com-puting market matures. In agreement, Lipton in [48] admits that the complexity and cost of switching (or porting) a cloud service to a different provider is often under-appreciated until it is too late. Therefore it can be claimed that as long as corporate data is not locked-in moving to another cloud provider is just a matter of en-during a switching cost. Such cost can be reduced by employing best practices such as choosing cloud pro-viders that support: (i) the use of standardised APIs wherever possible; (ii) wide range of programming languages, application runtimes and middleware; (iii) as well as ways to archive and	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Advances, Systems and Applications (2016) 5:4 Page 11 of 18informative example in this context is seen in research in [50], arguing that many cloud providers are con-cerned with the loss of customer that may come with standardisation initiatives which may flatten profits, and do not regard the solution favourable. Based on our research findings, from a business perspective, we sug-gest the following as key measures to improve	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	1) the quality of service (QoS) guarantee, 2) data protection and metadata ownership, 3) contract termin-ation, as well as 4) data export functionality. Further-more, as discussed in our previous study [4], in the absence of standardisation, UK businesses willing to outsource and combine a range of services from differ-ent cloud providers to achieve maximum efficiency, irre-futably, will experience difficulty when trying to get their in-	Ivon Miranda Santos

Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	10, we believe there are opportunities that exist for the regulatory and standard bodies to take the necessary action. One potential solution would be to standardise the APIs in such a way that businesses (or SaaS developers for example) could deploy services and data across multiple cloud providers. Thus, the failure of a single cloud provider/vendor would not take all copies of corporate data with it. Standard initiatives Cloud-specific standards are	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	TOSCA also enables a cloud service creator to provide the same plan or imple-mentation artefact in different languages (e.g. a plan can include the same functionality twice – in BPEL and BPMN). An application ported to the cloud using TOSCA can be composed of services provided by differ-ent cloud providers and a user can decide to a specific service with a similar one from a different vendor. CAMP Cloud Application Management for Platforms (CAMP) is an Oasis cloud-specific standard designed to ease the management of	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Considering that lock-in is un-desirable, and cannot be eradicated, then how can busi-nesses mitigate its associated risks when migrating to the cloud? From a portability perspective, it becomes critical that organisations' data is sharable between pro-viders, since without the ability to port data or applica-tion, it would become simply impossible to switch cloud service providers at all [60, 61]. Cloud portability is a sa-lient consideration to enable organisations migrate a cloud-deployed asset to a different provider and it is a direct benefit of overcoming vendor lock-in [62]. Gener-ally, reconfiguration of systems and applications to achieve interoperability is time/resource consuming and may require a considerable amount of expertise, which could be challenging for some organisations. Therefore, from a business perspective, portability should be seen as a key aspect to consider when selecting cloud pro-viders as it can both help mitigate lock-in risks, and de-liver business benefits. This means allowing applications, systems and data components to continue to work cor-rectly when moved between cloud providers' (hardware and/or software) environments [35]. Indeed, the need for organisations to easily switch cloud providers with their data alongside have been a consistent theme throughout the discussion presented hitherto. To expatiate on the question stated above, it is	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	ERP and CRM), including accounting and finance applications. At present, as indicated by the Cloud Industry Forum [39], cloud providers or vendors are bet-ter placed, if they ensure such capabilities like the trial or "test and see" strategy (whether completely free or paid for time limited pilot) is made available within their go-to-market strategy.	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Thus an emerging research agenda arises as to investigate: 1) ways to come up with multijurisdictional laws to support interoperability and portability of data across cloud pro-viders platform, along with effective data privacy and se-curity policies; and 2) novel ideas of avoiding vendor dependency on the infrastructure layer, platform, and through to the application layer as lock- cannot be com-pletely eliminated, but can be mitigated. However, these require, not just tools and processes, but also strategic approaches – attitude, confidence, comfort, and en-hanced	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	As a result, end-to-end deployment automation is efficiently enabled by employing DevOps approaches in cloud environ-ments. But, cloud providers such as Amazon and cloud frameworks such as OpenStack provide cost-effective and fast ways to deploy and run applications. However, there is a large variety of deployment tools and	Ivon Miranda Santos

Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Busi-ness decision makers are often unaware of how to tackle this issue. Our findings offer cloud computing con-sumers, service providers, and industry practitioners a better understanding of the risk of lock-in embedded in the complex, technologically interdependent and hetero-geneous cloud systems. In this respect, our research points to the need for more sophisticated policy ap-proaches that take a system-wide perspective to alleviate the current vendor lock-in	Ivon Miranda Santos
Opara-Martins2016-Critical_analysis_of_vendor_lock-in_and_its_i	CLOUD SERVICE PROVIDERS > Cloud provider	Fundamentally, the difficulty is attributed to the vendors' APIs which control how cloud services are harnessed, as cloud APIs are not yet standardized, mak-ing it complex for customers to change providers. Some cloud providers are concerned with the loss of cus-tomers that may come with standardisation initiatives which may then flatten their profits and do not regard the solution favourable. Therefore, we propose the fol-lowing strategic approaches to address the issues: (i) cre-ate awareness of the complexities and dependencies that exist among cloud-based solutions; (ii) assess providers' technology implementation such as API and contract for potential areas of lock-in; (iii) select vendors, platforms, or services that support more	Ivon Miranda Santos
Perrons2013-Cloud_computing_in_the_upstream_oil_and_gas_industr	CLOUD SERVICE PROVIDERS > Cloud provider	SaaS ''is at the top of the cloud computing stack. Here the cloud providers have created applications running on server farms that may themselves be geographically distributed'' (Garfinkel, 2011, p. 3). Salesforce.com, Facebook, Flickr, eBay, and Amazon Marketplace are	Ivon Miranda Santos
Perrons2013-Cloud_computing_in_the_upstream_oil_and_gas_industr	CLOUD SERVICE PROVIDERS > Cloud provider	But the potential gains offered by the cloud were sufficiently attractive that TC3 , a US-based healthcare services company with access to sensitive patient records and healthcare claims, moved several of their key applications to Amazon Web Services, a public cloud service provider (Armbrust et al., 2009).	Ivon Miranda Santos
Perrons2013-Cloud_computing_in_the_upstream_oil_and_gas_industr	CLOUD SERVICE PROVIDERS > Cloud provider	, 2009). It is therefore quite understandable that prospective users of the public cloud are sometimes hesitant to pursue this option precisely because it is difficult to ascertain exactly where one's data is being physically stored (Kamara and Lauter, 2010; Naone, 2011).4 Public cloud service providers are aware of these concerns, however, and have begun to offer servers and storage facilities in multiple legal jurisdictions. For example, both Amazon Web Services and Microsoft Azure have servers physically located in the United States and Europe, and both firms' customers are welcome to keep data in either region based upon their	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	TOSCA [3]). Cloud providers are nowadays also concerned about portability (e.g. IBM and HP are supporting to OpenStack initiative, while Amazon and Microsoft are investing in virtual machine	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The porting process of customer application and data is also often triggered by changes of the offers of the providers. The Cloud service providers can be interested to enhance their own Cloud resource and service offers to be more attractive in a highly dynamic market mainly by improving the quality of their resources and services. However agreements with other providers are possible (or even overtakes) in the case they provide services with particularities not provided elsewhere or	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The porting process of services is usually triggered by the operational changes. If the Cloud portability is ensured, third parties are able to be developed, acting as intermediaries between multiple customer and multiple Cloud providers, enabling deployments according the customer requirements to the appropriate Cloud and adaptation to the current status and consumption conditions of the multiple Cloud services. The porting process of data, applications or services is usually triggered at customer request	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The porting process is usually triggered on demand basis. The Cloud service providers are interested to use other provider services to ensure backup-ups to deal with disasters or scheduled inactivity. The	Ivon Miranda Santos

Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	3. Service portability or platform portability is the ability to add, reconfigure and remove Cloud resources on the fly, independent on the Cloud provider. Data portability is achieved when application data can be retrieved from one provider and imported into an application hosted by	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud interoperability is the ability of diverse Cloud services, data and applications to work together. It is mainly a concern for Cloud service providers to ensure the proper functionality of their services with the external world (even with services of other Cloud providers). Usually it assumes a previous knowledge or agreement of the systems with which the current one will inter-operate. Therefore the issue appears mainly in the case of Federations of Clouds, that are based on agreements between Cloud providers. The customer of the Cloud service is usually not aware of the Cloud interoperability facilities of the Cloud provider which whom is in agreement. Moreover,	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Intracloud and federation	Therefore the issue appears mainly in the case of Federations of Clouds, that are based on agreements between Cloud providers.	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	Moreover, regardless of the solution type, a com-mon approach is creating an abstraction layer that seeks to hide the differences between various Cloud services. The abstraction layer is agnostic to the Cloud services by hiding or wrapping the proprietary technologies of particular Cloud providers. Moreover the abstraction layer prevents developers from being bound to specific	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The classical way to bust the portability is the adoption of standards and open source. Surely they are important mostly for the Cloud providers and service developers, and not in a similar degree, for the consumers. Tables 4.1 and 4.2 are pointing towards the most important standards for Cloud portability, and,	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	Moreover, its DevStack enable the run of a OpenStack instance on a laptop or inside one VM. The mOSAIC open-source PaaS is offering two level of abstractions: from the Cloud provider technologies as the above mentioned technologies, but as well as from the classical synchronous programming style. The applications	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The Personal Testbed Cluster (PTC) allows the development of the applications on a desktop and test on few virtual machines (as much as the desktop allows) and later on the seamless transfer of the applications into Private or Public Clouds. CompatibleOne is based on a platform and a model for the description, aggregation and integration of distributed resources provisioned by heterogeneous Cloud service providers. Its	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_an	CLOUD SERVICE PROVIDERS > Intracloud and federation	Provides a federation layer support for bringing Cloud providers together.	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The meta-model serves is an abstract representation of the APIs and Cloud functionalities. Bernstein and Vij [31] proposed a mediation mechanism capturing the features of a Cloud provider in-frastructure, and logically groups and exposes them as standardized units. The mediation mechanism uses a resource catalog	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	Cretella and Di Martino [33] proposed an approach to perform automatically the enrichment of API with semantic content and the alignment of software. The approach aimed at analyzing the functionalities and features offered by Cloud service provider, through an automatic analysis of their APIs, and building a semantic representation that is linked to the application and functional domain to which the API refers. Dukaric and Juric [34] proposed a unified	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	Three levels of abstraction are considered by MODAClouds: CCIM, the Cloud enabled Computation In-dependent Model to describe an application and its data; CPIM, the Cloud-Provider Independent Model to describe Cloud concerns related to the application in a Cloud agnostic way; and CSPM, the Provider Specific Model to describe the Cloud concerns needed to deploy and provision the application on a specific Cloud. CCIM	Ivon Miranda Santos

Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	It is expressed in terms of a typical Entity Relationship diagram and enriched by a meta-model that specify functional and non-functional data properties. The CPIM Data Model describes the data model in terms of models being typically offered by Cloud providers, without referring to a particular one. Since the majority of available data storage software provides services that include distributed file system, NoSQL solutions, and blobs, these three models are considered at the	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The models are conceived for graph data, hierarchical data and flat data. The CSPM Data Model describes data structures implemented in the Cloud providers. The following families are considered: relational data, hierarchical data, flat data, key-value data, column-based data.	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	Standards. Standardization is not an appealing solution for some Cloud service providers. The providers are interested to differentiate themselves	Ivon Miranda Santos
Petcu2014-Portability_in_clouds_Approaches_and_research_opportu	CLOUD SERVICE PROVIDERS > Cloud provider	The portability issue is therefore an issue for the management and governance levels where automation should be achieved as much as possible. Limitations of abstraction layers include maintenance in response to changes made by a Cloud provider, and the limited coverage of provider functionalities. The mix-in of services from different providers can be a strong argument in using an unique entry	Ivon Miranda Santos
Rai2015-Exploring_the_factors_influencing_the_cloud_computing_a	CLOUD SERVICE PROVIDERS > Cloud provider	In this phase, a detailed assessment of the existing IT environment is done. The objective is to understand the applications that are appropriate for moving into the Cloud [P2] [P15] [P16] [P18], decision making regarding which cloud provider to choose [P3] [P5] [P6] [P9] [P13] [P16], which part of the application to be migrated	Ivon Miranda Santos
Ranchal2020-Disrupting_healthcare_silos_Addressing_data_volume_	CLOUD SERVICE PROVIDERS > Cloud provider	The aim of this paper is to highlight the challenges of large-scale healthcare data acquisition from multiple sources and provide guidance on leveraging cloud for building an HDI service for regulated environments. Thus, we have generalized the requirements, proposed design pat-terns, and provided a reference implementation of the HDI service without making it specific to a healthcare solution, cloud provider, or technology platform. However, these require-ments are captured and the proposed design validated through extensive work with multiple	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	What makes Cloud computing novel is the possibility of an almost immediate resizing of resources on a pay-as-you-go usage model. With companies moving forward with various cloud initiatives, cloud consumers are discouraged from relinquishing their control of the infrastructure to the cloud providers. The rivalry among cloud providers to stay competitive in the market makes it necessary to lock-in its customers, and there-fore customers cannot migrate easily to another due to non-interoperable APIs (Appli-cation Programming Interface), portability and migration issues. In addition, today's cloud users are mobile	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	To clinch the cloud advantages to its users, lots of cloud providers have emerged in various spaces each one trying to cut an edge over others in terms of service quality, cost, or durability. If there's any new service offering or monetary benefit, or a cloud service outage of the existing provider, technically, any user would be interested to migrate to the new provider. Even big giants such as Amazon have cases of cloud service outages, where its major clients Reddit and Quora could not shift to another provider immediately,	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	On one hand, cloud computing has relieved the customers from the initial invest-ment in hardware and the tiring task of managing the infrastructure, while on the other, it constraints the clients to stick to only one provider. But, too often than not, cloud users establish contract with a certain provider without much upfront thought as services are so easy to sign up and use. At some point later, when terms and conditions change, users get locked-in	Ivon Miranda Santos

Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	Portability, Interoperability, Federation, and Multi-Cloud. When two cloud providers can communicate with each other, it is Interoperability. When a cloud app works across heterogeneous cloud providers, it is Portability. When mul-tiple cloud vendors interact coherently to achieve a custom task to achieve either peak performance or cost efficiency, it is Federation and when a third-party tries to ease the communication among multiple cloud providers, it is Multi-Cloud. Gener-ally, to eliminate vendor lock-in, an application needs to be portable and purposely designed to	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Intracloud and federation	Portability, Interoperability, Federation, and Multi-Cloud.	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	Hence, to harness the power of cloud, there is a need for an integrated solu-tion that surpasses the technical barriers of data and services mobility, application portability, and vendor lock-in. There needs to be a single point of contact through a middleware for ensuring that a single application works on all cloud provider environments irrespective of the programming base it is relying on. The crux of the middleware lies in identifying the suitable APIs that can work across providers in servicing mobile clients. To understand the differences in the API set, a comparison is made on the differences in the invocation style of the cloud providers. The basis for defining the APIs for solving the portability issue is identified and the	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	The two deliv-ery models that offer the sequential and simultaneous mode of services are the Federated and the Multi-cloud.4 Federated cloud is where all cloud providers have an agreement to rent/lease resources to others for some cost benefits. During this process, the customer is not aware of any of the federal agreement among these cloud providers. He just gets the resources he requested for. In Multi-cloud, the end-consumer relies on a broker or intermediary who dynamically approaches the given set of providers, negotiates the terms of service consumption, programmat-ically provisions the resources and ensures seamless utilization of multiple cloud resources. The broker also takes care of the heterogeneity in the programming envi-ronments of the cloud providers while negotiating the terms of service consumption. Thus, through interoperable APIs and standard protocols, interoperability can be achieved in the case of	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	A provider can scale in terms of resources and offer attractive prices to customers based on agreements with other providers. Once the expected load cannot be satis-fied by the existing provider, resources from other clouds can be leased. Any spare and unused capacity of the provider can also be shared with other providers	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	Many large customers of Amazon such as Reddit and Quora were down for almost a day. The outage from a provider such as Ama-zon Web Services (AWS), that owns roughly a third of the global cloud market reignited debate on the risks of public cloud. However, Amazon's cloud outage was not the first, and it certainly would not be the	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	• Constrains on new locations and associated legal issues Leading cloud service providers have established data centers worldwide. However, it is not reasonable to expect that a provider should have established data centers in every part of country	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	Similarly, smaller organizations would require strong collaboration with other providers without investing heavily on its capital. Hence, the cooperation among cloud providers is required to lower the overall costs and optimize the energy used during the execution of the tasks. • Better SLA to consumers To stay competitive in the market, SLA definitions vary considerably among the major cloud providers. Amazon promises that its Elastic Compute Cloud (EC2) ser-vice will be available with an annual uptime percentage of at least 99.95% during the service year, compared with	Ivon Miranda Santos

Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	A clause in the Rackspace SLA6 definition states that its datacenter infrastruc-ture will be available 100% of the time in a month, excluding scheduled mainte-nance. Similarly, cloud providers handle SLA violations differently. Providers such as 3Tera7 automatically detect SLA violations and credit the cost directly to the application owner's account whereas Amazon and Rackspace expect the application owner to prove the SLA violations	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Tools that can do are Cloud4SOA for semantic-based PaaS offering,31 REMICS for combining model-driven approach with agile practices,32 and Multi-Cloud DevOps Alliance (MODAClouds) for model-driven development of multi-cloud operations.33 For this, model-based solutions are becoming increasingly popular in cloud com-puting as they provide domain-specific modeling languages and frameworks that enable architects to describe/select/adapt multi-cloud environments.	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Model-driven engineering is employed in a new technique called Cloud Blueprinting. Cloud Blueprinting — A Cloud Blueprinting offers a means to rapidly and eas-ily deploy pre-built, pre-configured, pre-optimized application payloads on virtual resource pools on the cloud and helps configure multiple cloud environments to meet application requirements and policies. It also includes a detailed deployment plan and an integration solution description, and abstracts the	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	The lack of for-malization hinders the understanding of the models, thus complicates the inter-operability in multiclouds. Reference Architecture for Semantically Interoperable Clouds (RASIC), Cloud Provider Independent Model (CPIM), Open-source API and Platform for Multiple Clouds (mOSAIC), and UCI enable semantic interoper-ability across clouds for ensuring portability. Service-Oriented Computing View — Web services are well-known Service Oriented Architecture (SOA) implementation models that could successfully inte-grate heterogeneous services from various service providers like	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Intracloud and federation	Cloud federations using meta-brokering, cloud brokering, and on-demand service deployment Fog Library-based service Institute of Electrical and Electronics Engineers (IEEE P2301) Standard for Intercloud Interoperability and	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Intracloud and federation	StratusLab Simplifies image creation and federation in the cloud	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Intracloud and federation	Product Cross-platform APIs Language Portability Federation Multi-Cloud IaaS PaaS SaaS	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	The Web service protocols implement Remote Procedure Call (RPC) calls over the Web, but differ in functionality such as caching, security, request/response handling, and message optimization and so on. To understand the impact of these technologies over today's cloud APIs, we studied the APIs of three storage providers. All three storage providers' offers services to upload a file, store it in cloud storage, retrieve it, and share it amongst other users. To understand the differences in the API set that they expose, we	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	The invocation strategy for three cloud services have been compared in the above figure, and it is evident that all three cloud services perform the same operations, but expect a different invocation style. One of the cloud providers expects the request in the form of SOAP and the other two expect the request in the form of REST. Even with the REST style of invocation, the parameters are	Ivon Miranda Santos

Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	Multicloud Middleware for Mobile Devices Cloud Interoperability is a very challenging task because of the existence of Cloud API propagation74 where each cloud provider provides its own set of Web services and Application programming Interfaces. Next generation mobile applications are focusing in the combination of different cloud capabilities from multiple clouds for the creation of composite services that are not tied to cloud specifications, and for transferring data	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	To access a cloud service from a smart-phone, the code has to necessarily undergo some change when compared to a client code written for a Personal Computer. For instance, to access a SOAP service of a cloud provider, the Android platform uses a light weight library called the kSOAP2 library.75 SOAP introduces some significant overhead for Web services that are problematic for mobile devices. kSOAP2 is introduced to handle such concerns. Thus, the problem today is in determining exactly what	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	The mobile-middleware interaction happens initially through a built-in Open Authorization (OAuth) procedure. At first, the middleware registers with different cloud provider APIs, and stores it in par with the FUSION API. When a mobile application tries to delegate a mobile task to the cloud, it sends a request to the middleware with the name of the provider, task to be performed, and any other parameters associated with the task. Upon receiving the request, Business Logic & Orchestration process is initiated where the mapping of the middleware API with the vendor API is performed and to suit the vendor	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	FUSION middleware. of routines creates a new request, unlike, one given by the mobile client, and this request in turn matches the actual request required to invoke the cloud provider's API. Similarly, upon receiving the response from the cloud vendor, the middleware transforms and optimizes the response to fit the	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	The FUSION model is built as an open source and portable PaaS platform. It works on top of IaaS and is a deployable service, meaning any client can deploy the FUSION model on their environment, and use it as an agent for supporting dynamic negotiations with multiple cloud providers for assisting mobile cloud applications. The FUSION framework is designed and implemented in a service-oriented fashion where the clients are the mobile devices, and the server is the FUSION PaaS plat-form, which provides a runtime	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	It works on top of IaaS and is a deployable service, meaning any client can deploy the FUSION model on their environment, and use it as an agent for supporting dynamic negotiations with multiple cloud providers for assisting mobile cloud applications. The FUSION framework is designed and implemented in a service-oriented fashion where the clients are the mobile devices, and the server is the FUSION PaaS plat-form, which provides a runtime environment for tasks execution in a multi-cloud environment.	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Emergence of Middleware platform becomes a brokering system offering a collection of tools to build, control, and establish multi-cloud environment for mobile cloud applications.	Ivon Miranda Santos
Ravi2019-Emergence_of_middleware_to_mitigate_the_challenges_of_	CLOUD SERVICE PROVIDERS > Cloud provider	Conclusions and Future Directions Since the birth of cloud computing, several providers have come up with specific offerings in terms of infrastructure, or compute or software. Such heterogeneity impedes using cloud services unless they are going to stick to the same provider. Various academic and business forums have taken up this issue seriously and are working to create a unified method of utilizing multiple cloud	Ivon Miranda Santos

Raza2019-A_review_on_security_issues_and_their_impact_on_hybrid	CLOUD SERVICE PROVIDERS > Cloud provider	I. INTRODUCTION Cloud computing topic has lot of rapid innovation on Internet from cloud service provider such as Amazon, Open Stacks EC2, through different types of virtual data centers operate across different types of IT environments. Gaining the several benefits, cloud computing provides a more elasticity enabling the on demand approach to an elastic pool of shared computing [1], [2].	Ivon Miranda Santos
Raza2019-A_review_on_security_issues_and_their_impact_on_hybrid	CLOUD SERVICE PROVIDERS > Cloud provider	Recently, survey covered that many enterprises are rapidly adopting a multi-cloud approach using different cloud service vendors to support their IT infrastructure [3]. According to survey respondents, Microsoft Azure use 58%, and Amazon Web Services use 52% as their cloud platforms providers. Additionally, Google Cloud use 19%, Oracle Cloud use 9%, and RackSpace	Ivon Miranda Santos
Raza2019-A_review_on_security_issues_and_their_impact_on_hybrid	CLOUD SERVICE PROVIDERS > Cloud provider	Data security refers to data confidentiality, integrity, authentication (CIA) in cloud [18]. A. Compliance with Regulatory and Policy Requirements Not only you have to compensate public cloud and private cloud provider are in compliance audit practices, but you also must demonstrate coordination of other third parties or open-source tools between both clouds is compliant [19]. B. Poorly Constructed SLAs Many cloud providers such as Amazon, Microsoft, Google and IBM support a large amount of customers by enhancing their web services. To make sure that public cloud provider can demonstrate the infrastructure meet those commitments, options and incentives detailed in	Ivon Miranda Santos
Repschlaeger2012-Cloud_requirement_framework_Requirements_and_e	CLOUD SERVICE PROVIDERS > Cloud provider	Abstract Due to the fast growth, Cloud Computing has become a non-transparent market with providers and customers willing to adopt it. Furthermore, many offers only partially meet customers' requirements and it is not clear how exactly Cloud	Ivon Miranda Santos
Repschlaeger2012-Cloud_requirement_framework_Requirements_and_e	CLOUD SERVICE PROVIDERS > Cloud provider	A decision support policy called Customized Bid-Price Policy is proposed by Anandasivam and Weinhardt (2010). In order to increase customer loyalty Cloud providers have to address their service quality weak spots and identify which factors are crucial for continued Cloud usage	Ivon Miranda Santos
Repschlaeger2012-Cloud_requirement_framework_Requirements_and_e	CLOUD SERVICE PROVIDERS > Cloud provider	Furthermore, we divided the scope of the requirements into criteria associated with the provider or related directly to the Cloud service in particular (see Figure 2). Provider requirements describe the characteristics of the underlying infrastructure of a Cloud provider, for instance this can be supplier certifications, IT infrastructure features or data center locations. Service requirements, however, describe the service	Ivon Miranda Santos
Repschlaeger2012-Cloud_requirement_framework_Requirements_and_e	CLOUD SERVICE PROVIDERS > Cloud provider	Costs Payment and pricing models are shaped by monetary considerations regarding the decision to choose Cloud Computing and a particular provider. The payment opportunities include the possible payment method (e.g. credit card or bank transfer), the time of payment (pre-paid or post-paid) and which level of granularity is priced	Ivon Miranda Santos
Repschlaeger2012-Cloud_requirement_framework_Requirements_and_e	CLOUD SERVICE PROVIDERS > Cloud provider	Furthermore, providers can exploit the evaluation criteria to enhance their business portfolios and focus on the right aspects of Cloud services. On the other hand customers will be guided by means of this framework to adopt and implement Cloud solutions, especially for selection and comparing providers or to advance the comprehension of Cloud Computing. The consequence is a shift from a subjective service assessment to a mostly fact-based performance selection where the realization of service requirements is gaining importance. In this context Cloud integrators and aggregators are becoming more relevant to advice customers and to realize a Cloud ecosystem which allows the combination and communication between several Clouds and services of different providers. A limitation of the presented framework is the lack of prioritization of the Cloud requirements and	Ivon Miranda Santos

Repschlaeger2012-Cloud_requirement_framework_Requirements_and_e	CLOUD SERVICE PROVIDERS > Cloud provider	The customer has to decide individually in which way he wants to use this framework, dependent on its purpose. This can be quite different based on the possible use cases (e.g. provider portfolio design, customer Cloud service selection process, provider benchmarking) of this framework. In our future research a next step will be the implementation of the framework within a practical	Ivon Miranda Santos
Repschlaeger2012-Cloud_requirement_framework_Requirements_and_e	CLOUD SERVICE PROVIDERS > Cloud provider	Furthermore we are planning to conduct several case studies with Cloud customers to evaluate and prioritize the framework and its requirements. The framework will be applied to different IS strategies both at providers' and customers' side to derive associated Cloud strategies and recommendations for the adoption and the portfolio management. Another future research field is the Cloud management. This includes the controlling of the relationship between provider and customer in the Cloud ecosystem and the measurement of respective Cloud services. Until now, only first attempts exist to benchmark Cloud	Ivon Miranda Santos
Rosati2018-Making_the_cloud_work_for_software_producers_Linking	CLOUD SERVICE PROVIDERS > Cloud provider	Finally, the actual capacity of the offered cloud service may fluctuate over time affecting potential economies of scale and application performance. Only the cloud service provider, and not the SP, can monitor the underlying service availability thus, the first problem is right-scaling i.e., to size a predicted workload to a machine (configuration)	Ivon Miranda Santos
Rosati2018-Making_the_cloud_work_for_software_producers_Linking	CLOUD SERVICE PROVIDERS > Cloud provider	4.2 Architecture Selection and Cost/Revenue Prediction From an SP perspective, the selection criteria of a cloud provider include fees and billing model. Many IaaS providers offer monthly basic subscription fees with additional fees for premium	Ivon Miranda Santos
Rosati2018-Making_the_cloud_work_for_software_producers_Linking	CLOUD SERVICE PROVIDERS > Cloud provider	Further studies may account for more complex models suitable for larger and more mature organizations. Similarly, we limited our case study to one cloud service provider and a small number of services. Future studies may seek to compare functionality, quality and costs, but this stage has been neglected in the literature (Gilia and S. Sood,	Ivon Miranda Santos
Rosati2018-Making_the_cloud_work_for_software_producers_Linking	CLOUD SERVICE PROVIDERS > Cloud provider	pay-per-hour models towards payment by business cycles are emerging in PaaS, linking the SaaS provisioning costs for the software producer with the platform. Cloud service providers are also innovating in ways that will impact how software producers conceptualize costs and pricing. For example, AWS Lambda is a compute service where code is uploaded and the Lambda service executes the code using the AWS infrastructure.	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	1 3 CSO-ILB: chicken swarm optimized inter-cloud load balancer for elastic containerized multi-cloud environment Mufeed Ahmed Naji Saif1 · S. K. Niranjan1 · Belal Abdullah Hezam Murshed2,3 ·	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Generally, most of the existing load balancing techniques sufer from performance degradation due to the communication over-heads among the containers. Moreover, less attention is given to stabilize the load in a multi-cloud environment. Therefore, to overcome this problem, there is a need to develop an elastic load balancing method to improve the performance of cloud systems. This paper proposed an autonomic CSO-ILB load balancer to ensure the elasticity of the cloud system and balance the user workload among the available containers in a multi-cloud environment. The concept of multi-loop has been uti-lized in our	Ivon Miranda Santos

Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Cloud provider	However, provisioning the required num-ber of cloud resources for executing business processes and workfows in a cloud environment is still a major issue; therefore, when the number of provisioned resources is insufcient to meet the demand (under-provisioning), the services of cloud users may get delayed, as a result, SLA violations increased. On the other hand, when the provisioned resources exceed the demand (over-provision-ing), the cloud provider compaction cost increases [1]. It can be perfectly served only if the resources are fairly provisioned to applications' workload according to demand. Enhancing the efciency of resource provisioning provides high-quality services to cloud users, maximizing the cloud provider's benefts [15].1113 1 3	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Cloud provider	It efciently provides cloud resources to deal with large business processes [18, 19]. It provides smooth execution of many busi-ness workloads satisfying the objectives of both cloud users and providers [20, 21]. Auto-scaling strategies decide on the scaling criteria to be vertical, horizontal or hybrid based on the resources' dynamic nature	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	When the resources in the cloud cannot process the huge business processes, the cloud elastic-ity is declined, and the solutions become unfeasible [27]. Load balancing in a multi-cloud environment ofers performance improvement and elasticity to process huge business tasks within a minimum time. Also, the auto-scaling mechanisms improve the efciency of the cloud environment, thereby refecting the overall reputation [28, 29].	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Cloud provider	The method integrated Ant Colony Optimization with an Artifcial Bee Colony algorithm to balance the load between the VMs in the cloud. The technique satisfed the users and the cloud ser-vice providers by achieving maximum resource utilization. Constrained load balancing schemes are followed in certain research for QoS satisfaction and to	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	3 Proposed methodology The cloud environment constantly receives dynamic workloads from multiple users. Therefore, proper scheduling is required to assign appropriate resources to the incoming workloads.	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	This bio-inspired algo-rithm efciently balances the load on the overloaded container by migrating the tasks to the appropriate under-loaded container in the datacentre. Moreover, a self-adaptation system based on an autonomic MAPE loop is utilized to deal with the dynamic changes in the multi-cloud environment. Figure 1 shows the	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Cloud provider	These tasks are said to be deadline constrained tasks if they have a deadline for execution. The deadline violation leads to a certain penalty, such as cost for the cloud provider. Thus, the comple-tion time for executing all the tasks should be	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The utilized containers are categorized into three types based on the load (i) over-loaded, (ii) balanced, and (iii) under-loaded containers. The load balancer con-centrates on the over-loaded containers and balances the load equally between all the available containers throughout the multi-cloud environment. It ensures a bal-ance between the containers while assigning resources for task	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	3.2.1 Automatic adaptation The automatic adaptation or the self-adaptation module is the major module that allows the containers to adapt to the changes recognized in a multi-cloud environ-ment. The user tasks are dynamic in nature; hence cloud containers must be	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The managed element incorpo-rates the application logic, which stays as a medium for directing the observed input from the environment to the system. Figure 3 depicts the working of a self-adaptation module with a multi-loop in a multi-cloud environment. The adaptation module obtains information from the environment and decides the actions taken to distribute the load among the available containers	Ivon Miranda Santos

Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	and CMODLB approaches attained 70.28%, 74.88%, 84.19%, 88.23%, 90.76%, 88.56%, 88.94%, 89.24%, 89.59%, 89.99% and 90.26% respectively. This article presents a novel CSO-ILB load balancing technique to balance the load in the containerized multi-cloud environment. The experiments proved that the proposed method could efciently balance the load among the available contain-ers by accurately choosing the	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The proposed CSO-ILB technique has been compared with the existing ACO, BCO, ASFLA and CSO algorithms. All the existing algorithms are also imple-mented in the multi-cloud environment to evaluate the performance improvement of the proposed approach. From the conducted simulations, it has been observed that the proposed approach obtained better and	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Cloud provider	The overall observations show that the improvement rate of the pro-posed model is 61% in terms of response time, 59% in execution cost, 45% in task migration count, 45% in make-span, 38% in energy utilization, 42% in idle time, 35% in reliability, and 30% in CPU utilization. Thus, it can be concluded that the proposed approach outperformed the other approaches in all the considered param-eters, providing efcient load balancing, ensuing the vertical and horizontal elas-ticity in a multi-cloud environment, and satisfying both cloud user and provider objectives.	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The overall observations show that the improvement rate of the pro-posed model is 61% in terms of response time, 59% in execution cost, 45% in task migration count, 45% in make-span, 38% in energy utilization, 42% in idle time, 35% in reliability, and 30% in CPU utilization. Thus, it can be concluded that the proposed approach outperformed the other approaches in all the considered param-eters, providing efcient load balancing, ensuing the vertical and horizontal elas-ticity in a multi-cloud environment, and satisfying both cloud user and provider objectives.	Ivon Miranda Santos
Saif2022-CSO-ILB_chicken_swarm_optimized_inter-cloud_load_balan	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Based on these decisions, vertical or horizontal scaling is performed to ensure the elasticity of the cloud environ-ment. The simulation is performed in the multi-cloud containerized environment using the ContainerCloudsim toolkit to prove the performance and efciency of the proposed approach. The results demonstrated that the proposed approach out-performed the other approaches regarding CPU utilization, make-span, response time, execution cost, reliability, energy	Ivon Miranda Santos
Sailer2018-Healthcare_application_migration_in_compliant_hybrid	CLOUD SERVICE PROVIDERS > Cloud provider	3 Related Work Cloud providers, such as Amazon [6], Google [7] and Microsoft [8] have been upgrading their services to comply with health regulations. Similarly, to IBM, a cus-tomer organization must first sign a written agreement called the Business Associate Agreement (BAA) before using IBM's	Ivon Miranda Santos
Sailer2018-Healthcare_application_migration_in_compliant_hybrid	CLOUD SERVICE PROVIDERS > Cloud provider	There is a rich body of literature that addresses the migration of legacy or enterprise applications to cloud [9–15] and its security and cloud hybrid aspects [12, 16–20]. Because migration to cloud is a major change for a service provider, carefully thought-out decisions factoring in technical, economical and compliance related aspects [16] need to be made and executed. Decision models may consider factors affecting migration in a holistic way and quantify them to provide a	Ivon Miranda Santos
Sailer2018-Healthcare_application_migration_in_compliant_hybrid	CLOUD SERVICE PROVIDERS > Cloud provider	Secure Gateway: The Secure Gateway is an interface that acts as an entry channel between the PaaS and the services running in the services providers cloud. During runtime, the secure gateway validates against the access directory the credentials presented by the API calls coming	Ivon Miranda Santos

Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Correspondence Amir Masoud Rahmani, Department of Computer Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran; or Computer Science Department, College of Science and Technology, University of Human Development, Sulaymaniyah, Iraq. Email: rahmani@srbiau.ac.ir Summary This paper presents an iterative mathematical decision model for organiza-tions to evaluate whether to invest in establishing information technology (IT) infrastructure on-premises or outsourcing IT services on a multicloud envi-ronment. This is because a single cloud cannot cover all types of users' func-tional/nonfunctional	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	On the other hand, multicloud brings several merits such as vendor lock-in avoidance, system fault tolerance, cost reduction, and better quality of service. The biggest challenge is in selecting an optimal web service composition in the ever increasing multi-cloud market in which each provider has its own pricing schemes and delivers variation in the service security level. In this regard, we embed a module in the cloud broker to log service downtime and different attacks to	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	This way, based on our method, to meet the security SLA (price, availability, integrity, and confidentiality), the broker can estimate and quantify financial losses owing to cloud disability; then, it finds low risky clouds in MCE to cover the user's business process. Another challenge is to select appropriate providers along with related services to cover the user's business process in large search space of the ever increasing multicloud market, which has mis-cellaneous competitive providers and handful services. One important question that arises is which provider can satisfy the business functional and	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	1. To present an iterative decision model with regard to cost and security risk perspectives to decide between internal IT development and cloud migration in a multicloud environment. 2.	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	Indeed, after the development of a business process model by organization management, its policymaker determines the business and security requirement and customizes them in the decision model. The bioptimization problem should be solved with regard to minimization of both cloud service cost and cloud cybersecurity risk to constitute a Pareto set from the ever increasing large search space of multicloud providers along with their bunch of services in the market, which is why we apply a genetic algorithm in a combinatorial algorithm to reach a Pareto frontier. Based on our system framework, finding web	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	More generally, enterprises adopt the hybrid architecture in which some services are deployed in on-premises, whereas other services are placed on off-premises, public cloud. Note that a single cloud provider can only focus on bounded business domains and seldom provisions the full functional/nonfunctional customers' requirements.48 We can enumerate several major cloud service providers such as Microsoft, Salesforce, Sky-tap, HP, IBM, Amazon, and Google. For instance, the Amazon web service provides 4 core services such as Simple Storage Service (S3), Elastic Compute Cloud (EC2), Simple Queue Service, and SimpleDB.49 In other words, Amazon currently offers storage capacity, computer processing time, message queuing, and	Ivon Miranda Santos

Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	The 4 aforementioned services can be considered principle services of CC. As such, Google and Microsoft provide business applications for customers, including document sharing, desktop soft-ware, search engines, e-mail services, and even CRM functions. It is obvious to conclude that no cloud service provider can satisfy all information system (IS) requirements.48 To support BC and relying on IT, multicloud integration leads to an innovative and reliable process for a technology delivery model.48 The atomic web services are composited to deliver	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	There exist several threats that can attack cloud datacenter components to disrupt routine tasks; hence, we classify the datacenter compo-nents, cloud threats, probability of materialization, target of attacks, which lingers to deliver a suitable level of security and its vulnerability in forthcoming sections to quantify multicloud security risks (cf, Section 3.3.2). One of the biggest challenges is to quantify the security risk in terms of monetary losses in a multicloud environment; the reason why we extend the AMFC factor is to determine the amount of cloud adopter financial losses due to cloud disability to meet the security objectives. Based on our method, a broker can estimate the	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	Finally, the method to quantify the security risks in economic factors is pro-posed. Furthermore, in a multicloud scenario, multiple providers are offering different virtual devices and computing units with different pricing and security levels in the market, which are taken into account as a bioptimization problem in the decision model.HOSSEINI SHIRVANI ET AL. 11 3.3.1 Security tenets According to broad research on security issues,14,38-41,69 the triple-vector feature (availability, integrity, and confidentiality)	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Our system framework is similar in system design as those in previous works.33,81,82 It has several modules that are illustrated in Figure 6. A multicloud environment (MCE) is one that contains a set of m clouds, whereas MCE={C1, C2 , … , Cm}, as in previous works.33,81,82 Every cloud includes a set of service files F = {F1, F2 , … , Ff}, whereas every service file contains a set of services S = {S1,S2 , … , Ss}, derived from off-line broker information in the primary phase, which is not the focus of this paper. Moreover, each cloud has its own pricing schemes and security level.	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	Hence, each workload W = {T1 , T2 , … , Tk} in the business process contains k tasks, and therefore, it needs k web services in the serial model. Meanwhile, each of the tasks can be supported by one cloud provider that has different18 HOSSEINI SHIRVANI ET AL. FIGURE 7 Web service composition in a sequence model [Colour figure can be viewed at wileyonlinelibrary.com] pricing schemes and security levels (in terms of threats, materialization probabilities, and disability to cover security requirements). Furthermore, the multicloud includes m different providers. As can	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	Moreover, security principles are necessary in both scenar-ios as a nonfunctional requirement. Moreover, after preprocessing phases by surfing over the Internet in a multicloud environment, there exist 40 cloud providers to provision web services and virtual resource needed. As in a traditional sce-nario, the same disk space is	Ivon Miranda Santos
Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	The genomic individual vector V = (6,6,24,35,24,24) from the Pareto set is one of the optimal solutions, which means that web services numbered 1 and 2 are deployed on Cloud6, web services numbered 3, 5, and 6 are deployed on Cloud24, and web service numbered 4 is deployed on Cloud35, respectively. It also does not violate constraints, ie, 3 providers are engaged along with cohosting web services numbered 5 (healthcare) and 6 (insurance) on the same cloud to decline communication costs. In the aforementioned instance solution, the costs of	Ivon Miranda Santos

Shirvani2018-An_iterative_mathematical_decision_model_for_cloud	CLOUD SERVICE PROVIDERS > Cloud provider	To make a final decision by a policymaker, Figure 21 depicts the amortized cost analysis for the 5 years of investment as a guideline. It shows that the fourth option, ie, Op4, is the best option provided that cloud providers continuously decrease 15% of total service costs for the sake of Moore's law and racing in the competitive market; accordingly, the third option, ie, Op3, is the worst option provided that cloud providers continuously increase 15% of total service costs for the sake of energy cost.32 HOSSEINI SHIRVANI ET AL. FIGURE 17 Comparison of the second year of investment between options [Colour figure can be viewed at wileyonlinelibrary.com] FIGURE 18 Comparison of the third year of investment between options [Colour figure can be	Ivon Miranda Santos
Shyamasundar2017-Information_flow_control_for_building_security	CLOUD SERVICE PROVIDERS > Cloud provider	A. A General Approach to Securing Hybrid Cloud Consider the architecture shown in Figure 2. In Figure 2 the cloud service manager (CSM) serves as the cloud manager for the organization that uses the internal cloud storage as well as interacts with public cloud providers. From Fig.	Ivon Miranda Santos
Shyamasundar2017-Information_flow_control_for_building_security	CLOUD SERVICE PROVIDERS > Cloud provider	An example hybrid cloud architecture a security standpoint, the CSM is responsible for managing the placement of data and computations on various clouds based on the organization's security policy, and the service-level agreements (SLA) that the organization has with the public cloud providers. From the perspective of an audit, the CSM is also required to maintain provenance information, for which it needs to keep track of the set of influencers of incoming data, for example the results that are being returned by the public cloud providers. The CSM can in fact provide a complete multi-level secure platform for computations on the organization's private cloud as it has full control over the resources of the private cloud. However, the CSM has to consider the public cloud providers as blackboxes where trust is achieved through the SLAs.	Ivon Miranda Santos
Shyamasundar2017-Information_flow_control_for_building_security	CLOUD SERVICE PROVIDERS > Cloud provider	Consider the example scenario depicted in Figure 3, where an RWFM monitor is integrated in to the CSM - represented as a thin layer on top of the private cloud. For simplicity, the figure depicts a hybrid cloud with only one public cloud provider attached, but the methodology works even with multiple public cloud providers attached. A typical usage scenario in a hybrid cloud is	Ivon Miranda Santos
Shyamasundar2017-Information_flow_control_for_building_security	CLOUD SERVICE PROVIDERS > Cloud provider	C. Discussion Zhu et al. [12] present a technique for scalable service and data migration in a collaborative cloud scenario where multiple public cloud providers store and maintain an organi-zations data. Their technique employs cryptographic schemes to	Ivon Miranda Santos
Shyamasundar2017-Information_flow_control_for_building_security	CLOUD SERVICE PROVIDERS > Cloud provider	An advantage of our approach is that the label provides information not only about the current data possession, but also a succinct summary (high-level) of its entire transaction history. For example, whereas the method of [12] can only tell us that a given piece of data is currently residing in a particular public cloud, our approach can provide additional information about which all cloud providers have influenced it during the course of its computation and storage. We have developed a dynamic labelling approach for mapreduce computations using RWFM that complements the approach presented in this	Ivon Miranda Santos
SOrheller2018-Implementing_cloud_erp_solutions_A_review_of_soci	CLOUD SERVICE PROVIDERS > Cloud provider	Delays or failures in support can create serious problems [3]. Organizations that need round the clock access to their ERP express significant concerns about the timeliness and quality of cloud provider support services [10]. We synthesized the findings in a concept matrix [6] which is presented in Table 2.	Ivon Miranda Santos

Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés. Automated Setup of Multi-Cloud Environments for Microservices Applications	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	HGustavo Sousa, Walter Rudametkin, Laurence Duchien. Automated Setup of Multi-Cloud Environments for Microservices Applications. 2016 IEEE 9th International Conference on Cloud Computing (CLOUD'16), Jun 2016, San Francisco, United States. pp.327-334, ff10.1109/CLOUD.2016.0051ff. ffhal-01312606v2ffAutomated Setup of Multi-Cloud Environments for Microservices Applications	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Meanwhile, microservice architectures are becoming increasingly popular in cloud computing as they promote decomposing applications into small services that can be independently deployed and scaled, thus optimizing resources usage. However, setting up a multi-cloud environment to deploy a microservices-based application is still a very complex and time consuming task. Each microservice may require different functionality (e.g. software platforms, databases, monitoring and scalability tools) and have different location	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Each microservice may require different functionality (e.g. software platforms, databases, monitoring and scalability tools) and have different location and redundancy requirements. Selection of cloud providers should take into account the individual requirements of each service, as well as the global requirements of reliability and scalability. Moreover, cloud providers can be very heterogeneous and offer disparate functionality, thus hindering comparison. In this paper we propose an automated approach for the selection and configuration of cloud providers for multi-cloud microservices-based applications. Our approach uses a domain specific language to describe the application's multi-cloud re-quirements and we provide a systematic method for obtaining proper configurations that comply with the application's require-ments and the cloud providers' constraints. Index Terms—multi-cloud; microservices; cloud	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	I. INTRODUCTION Multi-cloud computing is the use of resources and services from multiple cloud providers where there is no agreement between providers to offer an integrated view of the system [1]. It is up to the customer or a third-party to integrate services	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Cus-tomers must consider factors such as functional requirements, configuration options, pricing policy, data center location, availability levels, etc. Cloud providers have different manage-ment interfaces and use different concepts for their offerings, making them difficult to compare. In addition, each of the application's services may	Ivon Miranda Santos

Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	They may be written in different programming languages, using different application frameworks or databases, and may have different scalability and availability requirements. Thus, a cloud provider that supports one of the application's services might not support another. Also, local regulations may require data to be stored within a given region, imposing further constraints. We propose an automated approach for the selec-tion and configuration of cloud providers for multi-cloud microservices-based applications. Our approach relies on on-tology reasoning [3] and software product line techniques [4] to get from a high-level description of multi-cloud require-ments to a configuration for a multi-cloud environment. While some approaches deal with aspects of multi-cloud manage-ment [5], [6], [7], [8], [9], they do not take into account the rich variability that exists in cloud providers' configura-tion options, losing valuable insight. Work done to manage variability in the cloud [10] does not consider multi-cloud requirements. Our approach goes further than existing work by dealing with multi-cloud requirements for microservices-based applications, while considering provider configuration variability. Our key contributions are: • An approach to build multi-cloud environments that han-dles the intrinsic variability in existing providers. • A method for translating high-level multi-cloud require-ments to a set of provider specific feature	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	We propose an automated approach for the selec-tion and configuration of cloud providers for multi-cloud microservices-based applications. Our approach relies on on-tology reasoning [3] and software product line techniques [4] to get from a high-level description of multi-cloud require-ments to a configuration for a multi-cloud environment. While some approaches deal with aspects of multi-cloud manage-ment [5], [6], [7], [8], [9], they do not take into account the rich variability that exists in cloud providers' configura-tion options,	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Our key contributions are: • An approach to build multi-cloud environments that han-dles the intrinsic variability in existing providers. • A method for translating high-level multi-cloud require-ments to a set of provider specific feature	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Apart from these requirements, there are no further restric-tions on application services. Thus, when setting up a multi-cloud environment to deploy this application, we will be look-ing to optimize costs or improve the quality of service while complying with application requirements and constraints. Even from this simple example we can see that taking all relevant factors into account for setting up a multi-cloud environment can be a very	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Even from this simple example we can see that taking all relevant factors into account for setting up a multi-cloud environment can be a very complex task, which calls for automation and supporting tools. In this paper, we present an automated approach for the selection of cloud providers and generation of proper config-urations that considers the following concerns: Cloud providers heterogeneity: Cloud providers usually offer functionality as services at different levels of abstraction such as infrastructure (IaaS), platform (PaaS) and software (SaaS). Even at the	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	These differences com-plicate further the comparison between providers. Cloud providers variability: Cloud providers may have complex rules concerning their configuration. According to the provider, some functionality may only be available in a given region or for a given	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Some features may have conflicts while other may have dependencies. These as well as other complex constraints can be found in cloud providers and should all be considered to obtain a proper configuration. Multi-cloud requirements for microservices-based	Ivon Miranda Santos

Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	Microservices can be developed by different teams, relying on different technologies and methodologies and may therefore require functionalities at different levels of ab-straction. In a multi-cloud environment, microservices can be deployed across private and public clouds from different providers to implement scalability and redundancy mecha-nisms or to comply with location constraints.	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	A cloud provider expert is responsible for providing formal de-scriptions of cloud providers' offerings through feature models and ontology mappings. On the other hand, developers interact with the approach by providing requirements of a multi-cloud environment. These requirements are matched against providers' descriptions to	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	The service requirements are intended to describe the functionality required by a service to run. These can be virtual machines, runtime environments, databases, software management tools, or any other feature that is offered by a	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	The cloud variables describe conditions on the clouds where the services are to be deployed. This allows specifying requirements, such as, instances of a service should be placed in clouds maintained by different providers, or, that a given service should be deployed to a cloud located in a	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	While the tree hierarchy describes a com-position relationship between features, additional constraints allow for defining extra relationships between features. In our approach, feature models are used to model the variability in the configurations of a given cloud provider. This means that a feature model describes what are the services and resources offered by a given provider, how they are related	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	The feature models employed in our approach, as the one shown, are extended with cardinalities and additional constraints. Therefore, we rely on previous developments done on cardinality-based feature models [15] and on modeling cloud providers with feature models [16]. For expressing rel-ative cardinalities and the complex constraints found in cloud providers, we also rely on the results of our previous work on extending feature	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	This means that the maximum number of Gears in an Application is three when the Free plan is chosen. Feature models have already been used in [18], [10] to manage the variability in a cloud provider's configuration. However, in their approach the	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	But it is also due to the limitation of existing feature modeling constructs, which could not describe the complex constraints involving relative cardinalities that surface once we consider configuring multiple services through feature models. In a summary, by modeling cloud provider variability we guarantee that the configurations generated by our approach are valid according to providers' constraints. In addition, the use of feature models extended with relative cardinalities allows for modeling the complex constraints	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Similarly, provider specific concepts can be used to simplify the description of feature model mappings. In a summary, ontologies are used to bridge the gap between service requirements and cloud providers. By using ontologies we can describe service requirements that are as complex as an ontology class description and reason upon them to find cloud providers that may offer instances of	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	The following subsections provide more information about the implementation of these tools and their evaluation. A. Modeling To model the artifacts required by our approach, we de-signed three domain-specific languages for describing (i) multi-cloud requirements; (ii) cloud provider variability; and (iii) cloud provider mappings. We then used the xText [19]	Ivon Miranda Santos

Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	As illustrated in Fig. 5, an instance of this problem is described by the requirements of an application and a set of available cloud providers. From application requirements we have a set of services, which are assigned by the developer to a cloud variable through a set of instance groups (see Section III-A). On the other side, we have a set of cloud providers that offer varying functionality. A solution to an instance of this problem is an assignment from cloud variables to cloud providers, which is depicted as a set of dashed lines. Due to the number of providers, the search space	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Verification is done in three steps: 1) validating that assigned providers comply with cloud conditions; 2) checking that 1http:/	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	However, this may still require some reasoning over ontologies to identify, for example, that a cloud located in France meets the criteria of being located in WesternEurope. To do so, we translate a cloud condition into an ontology class, which represents the class of clouds that complies with the condition, and then verify if the assigned provider cloud is an instance of this class. Fig.	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	2) Mapping service requirements to provider features: After verifying that the assigned providers comply with cloud conditions we still need to check if each selected provider supports all functionality required by the services assigned to it. To do so, we use the cloud provider mappings to check, for each assigned service, if its required functionality can be mapped to a set of features in the provider's feature model. First each service is converted into an ontology class,	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	2) and its corresponding ontology class. Then, we use ontology reasoning together with cloud provider mappings to find a selection of features that provides an instance of this required class.	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	However, as there may be limits in the resources offered by a provider, conflicting features, or other constraints in cloud offerings, we still need to check if all services assigned to a provider can be deployed together and to generate a configuration for each provider. This process is done by evaluating the cloud providers' feature models against the feature selection expressions obtained in the previous step. This is a complex and time consuming task that involves translating the feature model to a constraint satisfaction problem	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Besides this, the output solution also defines for each selected provider a complete configuration of the corresponding feature model, detailing a hierarchy of feature instances that should be selected. Our strategy for processing application requirements enables us to get from a set of requirements for microservices-based multi-cloud applications to a concrete set of selected features in each cloud provider. By decomposing this process into three steps we avoid doing more	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	The application requirements were described using the domain-specific language for multi-cloud requirements and include 13 services, with 5 cloud variables and 15 instance groups. In addition, we elaborated feature models and on-tology mappings for four popular cloud providers:	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	This indicates, that despite the time needed to process and generate a valid solution, invalid assignments can be discarded more quickly and reduce the search space. D. Limitations Our approach focus on the selection and configuration of cloud providers for a multi-cloud scenario and does not deal directly with the deployment of applications. Generation of deployment scripts from feature models has been	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	We also still do not consider costs and quality of service for optimizing the selection as these depend heavily on application usage. Finally, for the conducted experiments, cloud provider feature models and ontology mappings were manually defined relying providers' documentation, and are thus susceptible to errors.	Ivon Miranda Santos

Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Several recent works were proposed to deal with aspects of the management of multi-cloud systems. CloudMF [8] relies on a domain-specific language and models@runtime to deal with heterogeneity across providers and support pro-visioning and deployment of multi-cloud systems. We also employ domain-specific languages for modeling requirements and provider descriptions, but in addition we also support the selection of cloud providers and variability management. The mOSAIC [7] and soCloud [25] projects propose a multi-cloud PaaS for interoperability across	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	[6] propose a constraints-based method for composing multi-provider environments. Like in our work, their goal is to find an assignment of services to cloud providers according to some constraints. However, requirements are defined as	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Like in our approach, ontologies are used for semantically mapping requirements to providers' offerings. However, both approaches do not manage variability and constraints of cloud providers configurations. Managing variability and heterogeneity in the cloud has also been identified as an important issue that is subject of substantial work.	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	However these approaches do not consider the variability in providers' offerings and apply reasoning upon predefined instances. The SALOON [10] approach also relies on feature models to capture cloud provider configuration options and ontologies to map from requirements to cloud features. However, it does not consider applications that can be composed of multiple services and do not support multi-cloud requirements. Our approach shares with existing work the use of ontolo-gies to deal with heterogeneity across cloud providers and of software product line techniques for managing variability in cloud provider configurations. However, our work takes into account variability at the provider level, not only for	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	However, the wide number of available cloud providers, their high heterogeneity and their intricate configu-ration options, make it very complex to exploit these benefits. In this paper, we describe an approach to deal with this com-plexity, by supporting the selection and configuration of multi-cloud environments for microservices-based applications. Our approach relies on a domain-specific modeling lan-guage for defining multi-cloud	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Cloud provider	Our approach relies on a domain-specific modeling lan-guage for defining multi-cloud requirements and a combina-tion of reasoning tools to obtain: (i) a valid assignment of application services to cloud providers and (ii) proper config-urations for these providers. We implemented this approach as a set of tools for	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud management tools	Our approach relies on a domain-specific modeling lan-guage for defining multi-cloud requirements and a combina-tion of reasoning	Ivon Miranda Santos
Sousa2016-Automated_Setup_of Multi-Cloud_Environments_for_Micro	CLOUD SERVICE PROVIDERS > Multi-cloud Environment and Management	[6] P. Wright, Y. Sun, T. Harmer et al., "A constraints-based resource discovery model for multi-provider cloud environments," Journal of Cloud Computing: Advances, Systems and Applications, vol.	Ivon Miranda Santos
Stavru2013-Challenges_for_migrating_to_the_service_cloud_paradi	CLOUD SERVICE PROVIDERS > Cloud provider	For that reason, we limited the extraction of challenges to: (1) for Service-Oriented Architecture we included challenges relevant for both service consumers and providers, as software migration could involve both developing of new services and using external ones; (2) for Cloud-Computing we included only challenges relevant for the cloud consumers, excluding challenges covering the development of cloud infrastructure, how security should be achieved within this infrastructure and other challenges more relevant for the cloud	Ivon Miranda Santos

Stavru2013-Challenges_for_migrating_to_the_service_cloud_paradi	CLOUD SERVICE PROVIDERS > Cloud provider	In cloud environment there might be no control (and even visibility in some cases) over these assets and no guarantees (even if there are strong service level agreement, strict standards, etc.) that the cloud provider would act in accordance to the interests of the organization and no external parties (or events) would significantly interfere in their relations (e.g. through business acquisition). Thus mistrust and lack of security and privacy might become the greatest barrier for the	Ivon Miranda Santos
Stavru2013-Challenges_for_migrating_to_the_service_cloud_paradi	CLOUD SERVICE PROVIDERS > Cloud provider	Cloud Computing and its challenges further affect the way agile methods and techniques could be incorporated into the Service Cloud Paradigm. Trust (O1), security and privacy (O3) of data and computation are as much important for the organization as for its customers, so the organization-customer collaboration, central to agile software development, might need to be extended to include the cloud provider (in order to increase transparency, visibility, responsiveness, etc., so needed for the building trust and confidence). Vendor lock-ins (O2) might further hinder organizational flexibility and agility (e.g. as one could not change its cloud provider effortless and in a timely manner), while external dependencies (O2) could decrease the business value delivered to customers (e.g. due to new requirements coming from the cloud infrastructure or the organization is pressured to use specific and expensive software licenses coming from the could provider, etc.) and could further decrease organizational responsiveness (e.g. due contracting). In terms of technical challenges, the maintenance and troubleshooting difficulties (T1), together with the lack of cloud support (T3), might require more involvement from upper management (in order to assure the	Ivon Miranda Santos
Tona2020-DPS-AA_Intranet_migration_strategy_model_for_clouds	CLOUD SERVICE PROVIDERS > Cloud provider	Functional Demonstration of Intranet over Cloud: At this phase, an Ideal Intranet Prototype is required to be designed, developed and demonstrated over the selected Cloud Service Providers Infrastructures.	Ivon Miranda Santos
Weerasinghe2022-Taxonomical_classification_and_systematic_revie	CLOUD SERVICE PROVIDERS > Cloud provider	AIOps concepts mainly focus on microservices [81]. Most of the cloud providers invent serverless architecture services and function as a service. Cloud consumers are moving towards serverless because it provides on-demand computing	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	The resources within a cloud can be owned or from a utility resource provider or indeed a combination of both. We have been developing and man-aging a large multi-provider cloud in field deployment for broadcasting applications with an active user community for several years that uses owned resources and resources bought from commercial providers. With the availability of large-scale resources from the increasing number of utility providers, mechanisms are required to enable resources to be added to and removed	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	In this paper we discuss a large-scale cloud infrastructure for digital media that has been in deployment for over two years; the infrastructure manages more than 2 petabytes of content for delivery to mobile devices, computers and to set-top boxes in the home. In particular, we consider the management of resources for the media services application cloud from a collection of resource providers. The appli-cation is hosted on a resource cloud consisting of owned infrastructure (organised as a collection of four private cloud	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	Restrictions apply.Aas providers), private cloud toolkits such as Eucalyptus[5], OpenNebula or OpenStack – as well as a number of user libraries such as libcloud.org, Dasein, jclouds, Deltacloud, etc. to allow users to talk to these APIs. The cloud APIs are often very different in form and in model since they conform closely to the internal model of	Ivon Miranda Santos

Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	In addition neither API, provider nor user libraries are static, requiring constant attention to keep provisioning code in sync with this evolution. A. Zeel/i To solve this problem we created Zeel/i (described in full in[6]), a broker whose model is abstracted somewhat from that of any cloud provider (providing a single model across all providers). Zeel/i also adds extensive XACML user and role-based rich operation access control, resource sharing, budgeting and eventing capabilities which can be used to prevent abuse/theft of credentials while allowing various groups access to observe	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	Users perform all provisioning and management operations through the broker, authenticating with their own identity (for instance, a user certificate). Access control can thus be performed based on a precise origin user before the call is forwarded to the Cloud Provider (using the cloud credential added to the Zeel/i broker initially). This approach allows access control and accounting to be aware of end users (whereas cloud provider APIs only show charges per account). Once a pool of providers are defined, an	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	While it is easy to create a scenario, simple pre-defined scenarios exist to get developers started. The advantage of handling provisioning with this service-specific cost-value proposition is that systems can automat-ically evaluate the cost of shifting an existing infrastructure to another resource tier or cloud provider. By constantly evaluating the reprovisioning cost as well as the runtime cost in another cloud it is possible to automate a system to transition cloud infrastructures as long as the runtime savings will	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	(The range of commercial providers we use is extensive and is designed to provide a genuine commercial resource marketplace to reduce our day-to-day costs.) Each of the resource cloud providers is managed identically as outlined above using the application centric and provider agnostic library–with each provider advertising available resources and their costs. A resource is selected by filtering those available according to the constraints specified for a service and a	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	The system attempts to manage transcoding operations to minimise cost within the delivery window, performing Just In Time conversion and opportunistically delivering content ahead of time in cases where there is temporary excess capacity. This opportunistic behaviour takes advantage of the unpredictable times involved with transcoding and the way in which cloud providers bill for resources (generally rounding up usage by treating part-hours of usage as full hours). At a broad level, the system benchmarks cloud	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Cloud provider	When the resources are returned the cost function then produces an estimate of the efficiency for each resource, selecting the highest-performing resource. An unfortunate reality of cloud systems is performance variation in seemingly identical resources: often this is due to a heterogeneous hardware at the cloud provider (e.g. a mix of AMD and Intel processors of varying generations) but performance can also be impacted by ”noisy neighbours”. Our system identifies under	Ivon Miranda Santos
Wright2011-A_commodityfocused_multi-cloud_marketplace_exemplar_	CLOUD SERVICE PROVIDERS > Intracloud and federation	[3] R. Buyya, R. Ranjan, and R. Calheiros, “Intercloud utility-oriented federation of cloud computing environments for scaling of application services,” in Algorithms and Architec-tures for	Ivon Miranda Santos
Zhou2017-Cost_reduction_in_hybrid_clouds_for_enterprise_computi	CLOUD SERVICE PROVIDERS > Cloud provider	In addition, while existing works have done a good job exploring the benefits of deploying applications in the simple two clouds environment(which contains both a private and a public cloud), they seldom evaluate the benefits of employing a hybrid cloud architecture with a private cloud and multiple geographically distributed public clouds. In fact, many large cloud providers (e.g., Amazon Web Services [9] and Microsoft Azure [10])	Ivon Miranda Santos

Zhou2017-Cost_reduction_in_hybrid_clouds_for_enterprise_computi	CLOUD SERVICE PROVIDERS > Cloud provider	A linear cost model is used for computing the value of $\beta_{i,\pi(i)}$ and $\beta_{i,j,\pi(i),\pi(j)}$, which matches the business model of multiple cloud providers [1]. Note that the value of $\beta_{i,\pi(i)}$	Ivon Miranda Santos