System Architecture for a Human Resource Management System

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Section 1: Introduction

A core aspect of organisations achieving their goals and missions is their Human Resources (HR). Human capital is an ever-increasing expense for organisations (Makarova, Shubenkova, & Pashkevich, 2019). Over the past decades, the increasing expense and complexity in managing human resources has sprung new industries dedicated to providing IT solutions. This demand has led to the development of a large array of Human Resource Management Systems (HRMS) to replace the traditional paper-based systems.

A HRMS is a combination of systems developed to aid the management of human resources (Rietsema, n.d.). Employment history, recruitment, payroll, employee attendance and holiday leave systems are all components that may make up a larger HRMS. An organisations HRMS solution may cater for small sized companies numbers in the 10s of employees, up to large scale industries with employees in the millions (McCarty, 2015).

As the scope of HRMS is quite large and can cover a wide range of various subsystems, for the purposes of this paper I will be focusing on an architecture for a HRMS dealing with employment history and recruitment. The proposed architecture has been designed to server small companies and can scale in size, to server large organisations managing millions of employees. The system will be used primarily by HR teams and will be maintained by HR admin teams.

Existing Systems Review

System Requirements and Challenges

The aim of the proposed HRMS is to maintain a record of current employee work history, including copies of their qualifications for audit and accreditation purposes. The system should also provide a capability for tracking and accepting applications for job vacancies, and interface with 3rd party job listing API's. Data privacy, access rights,

governance, system robustness and scalability are key requirements in the proposed HRMS.

There are several challenges to be addressed when implementing an architecture of this type. Maintaining strict privacy policies and data access is a key concern. HRMS may contain large amounts of sensitive employee information, the proposed architecture must consider the varying levels of access required. Modern organisations can afford very little down time of their HRMS, therefore ensuring system robustness and scalability is challenge that must be addressed.

Range of Existing Systems

The modern HRMS is comprised of several subsystems, as such there is a large variety of HRMS available to choose from. Some solutions target specific areas of HR needs, while others group many functions together to be a one stop solution for all HR tasks (Westfall & Davies, 2019). The complexity of an organisations HRMS can grow as the size and complexity of the organisation grow.

The HRMS landscape has been undergoing a change in recent years with the rise of cloud computing and Software as a Service (SaaS) Imron, Hidayanto, Fitriani, Nugroho, and Inan (2019). Traditional HRMS offerings such as Sage (Sage, n.d.) who specialise in payroll systems have begun to offer cloud based versions of their applications. Cloud computing has led to new innovations in the HRMS space with intelligent automated recruitment systems by MediBanks (MediBanks, n.d.).

Commercial Offerings

The HRMS market is a competitive industry which has a led to a variety of commercial offerings. Traditional large players exist in the market such as the previously mention Sage. Sage offer a range of services including payroll management and employee performance and time management solutions. Organisations can opt to use the full commercial package, single solutions, or a combination. Similar to many other HRMS offerings, Sage has begun offering a cloud-based solution.

Cloud based solutions and SaaS platforms however do raise questions surrounding the data ownership, rights and governance of potentially sensitive employee and job candidate data. MediBanks, previously mentioned, is a cloud based HRMS who addresses the concern of governance and ownership by providing public and private cloud solutions. While cloud computing solutions can reduce the initial cost of HRMS (Zhou, Tang, & Zhao, 2017), I do believe that for some aspects, particularly around data ownership and access, that organisations take all necessary precautions to protect employee and applicants data. While the cloud can provide convenience and cost savings for organisations, it is important that data rights are a priority concern.

The modularity of the available offerings allows organisations to choose their own stack to meet their needs. Incorporating additional modules or systems as the organisation grows in complexity provides flexibility. However, it is my opinion that mixing too many options from different vendors could lead to increased and unnecessary complexity. Careful analysis of how subsystems integrate with each other would have to be conducted before implementing a solution.

Innovation

Blockchain based HRMS have been proposed to combat inaccurate and fraudulent HR data. The accuracy of HR data is directly related to the cost and efficiency of HR teams. Some surveys have shown that up to 70% of potential job candidates have hidden information or provided inaccurate or fraudulent data (Wang et al., 2017). A HRMS utilising blockchain technology to track employment history can reduce an organisations exposure to such data.

Many HRMS systems are beginning to take advantage of cloud computing technologies. SaaS applications such as those offered by MediBanks provide public or private cloud HRMS systems for managing the recruitment of medical staff (MediBanks, n.d.). The SaaS offering also provides automated recruitment functionality.

Functionality Summary

For the purposes of this paper the architecture proposed is focused upon employment history and job recruitment. An overview of the required functionality for the proposed HRMS is shown in table 1.

Authentication	Providing and managing user login
Registration	New staff and candidate profiles
Authorisation	Levels of access i.e. functionality and data
Data Retrieval and View Management	Storing employee history, BLOB store for documents (uploaded CVs, qualifications etc.)
Data Persistence	Providing access and view rights only to those who need them
Intelligent Job Matching	Find and suggest suitable candidates in the system to recruiters
3rd Party API Integration	Allow users to view available jobs
Employee Search and View	Search and view current employee records
Provide Audit Access	Access for data required for audits (only providing required data)
Job Vacancy Search	Automatic posting to 3rd party applications

Table 1

Section 2: Proposed HRMS Architecture

Downtime for a HRMS can be unnecessary and costly to an organisation, as such any HRMS should ensure a degree of redundancy. As shown in figure 1, for this proposed architecture, each regional centre of an organisation is tasked with maintaining its own data and processing, as well as that of a neighbouring node. In the case of a regional centre's node going down, the discovery section of the architecture discussed later in this section, will forward requests to its paired node that has replicated the impacted nodes data and processes.

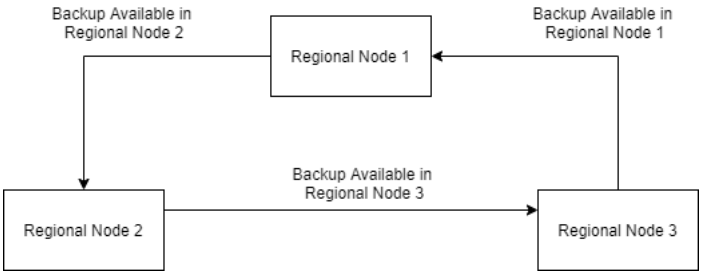

Figure 1. Regional Node Network for Redundancy

The proposed architecture shown in figure 2, is a traditional client to server relationship. The architecture utilises a hybrid cloud allowing for finer control over data access and usage policies. A hybrid model is proposed to provide leverage scalability in the presentation, API Gateway, and discovery layers through the public cloud, while maintaining control of user data and processing on a local, private cloud.

Persistence Layer

Data governance, privacy and ownership is a key concern of any HRMS. The proposed HRMS deals with sensitive employee and candidate data. Data and privacy policies can vary from region to region and it is important that each region maintains a strict privacy and data usage policy. The proposed architecture provides for traditional RDBMS and Blob stores. The Blob store is mainly concerned with uploaded documents i.e. copies of CVs and qualifications. The RDBMS is available for all other application data.

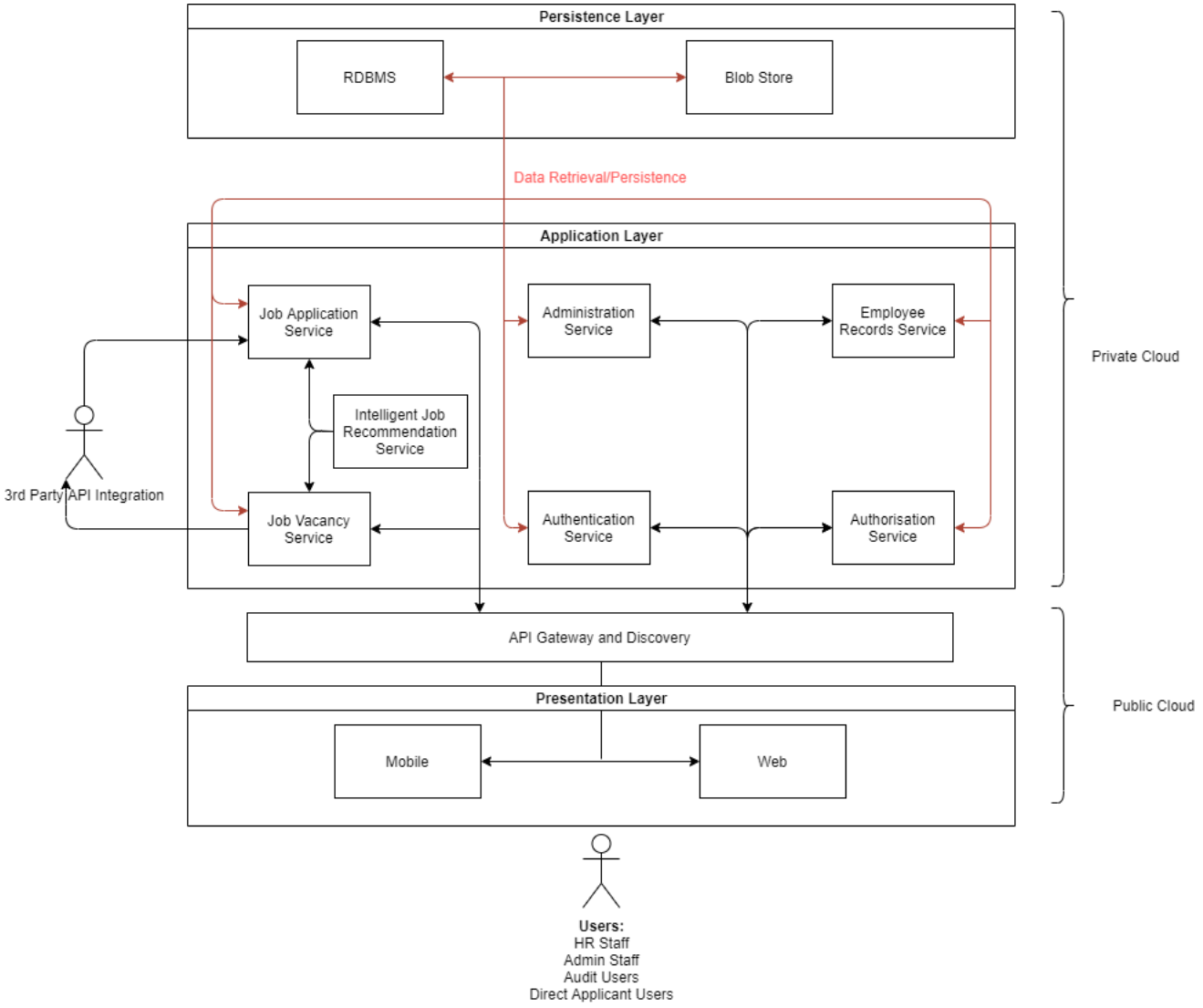

Figure 2. Proposed Architecture

API Gateway and Discovery

The discovery and API Gateway are deployed on a public cloud, this allows the system to take advantage of the scalable nature provided by a public cloud. As demand increases more instances or resources can be deployed to meet the requirements. Depending upon the domain or geographic location of a user, the discovery layer ensures that the API Gateway communicates with the correct node. In the event of a node going offline the discovery layer will re-route the API requests to the node containing its backup.

Presentation Layer

The presentation layer communicates with the public API, view management handled by the front-end client based on the interaction with the authorisation services. There are several views required to be managed by the presentation layer. Potential candidates should have access to job vacancies, external auditors may require access to existing employee records, HR staff require access to post new vacancies, review current employee and potential candidate data, administrative teams must be able to configure tooling etc.

Application Layer

The application layer is where the processing and business logic resides. There are several modules included in the proposed architecture, however more modules can be added as needed. The functionality is outlined in table 2.

API Gateway	Provide RESTful API for front client
Authentication Service	Manage user login and registration
Authorisation Service	Manage user access rights
Administration Service	Ability to configure settings and tooling
Employee Records Service	Manage employee records and qualifications
Job Vacancy Service	Manage job vacancy postings
Job Application Service	Manage candidate applications
Intelligent Job Recommendation Service	Smart module that monitors current and previous applicant history and qualifications to recommend to HR staff for active open jobs.
Third Party Integration	Post job vacancies and receive applications from third party websites i.e. LinkedIn

Table 2

Section 3: System Performance

Poor system performance in terms of latency, bottlenecks or downtime can cause unnecessary costs to an organisation. To address these concerns several considerations were made in the proposed architecture. A core aspect of the proposed design is it's distributed nature, which can provide many benefits in terms of a systems performance (Sun, Zhang, & Gao, 2019)

Replication is the storing and process data in multiple regions. This replication of data and processes does have several drawbacks. There are higher costs associated with hardware and maintenance and the bandwidth for transferring large amounts of data can be costly, however, these trade-offs can be justified for an organisation that requires a reliable and responsive system.

In the event of a node being taken offline, staff and users can continue to work by connecting to its neighbouring node. This may induce some additionally latency into the network, however this is negligible and is preferable to the system not being available. Depending on the organisation replication can occur at specified intervals, certain data may be replicated at more frequent intervals depending on its priority. The replication of data and processes can also be leveraged during system updates. A nodes infrastructure and system can be update without any loss of productivity as users on the node will be redirected to its neighbouring node during the update.

The structure of regional nodes can have the benefit of faster data access, particularly for large organisations with many locations spread across the globe. Rather than having a single central node where data must travel to and from globally, this architecture stores data close to its geographic region allowing for lower latency.

Another advantage provided by the distributed design is the reduction of potential bottlenecks in the system Yang, Peng, Feng, and Tian (2017). Rather than a single central processing and data store, each region has its own, therefore reducing the number of users on each node. However, there is one area that may cause a bottleneck. There is a common

portal in the discovery and API Gateway layer. A common routing node in a system is cause for concern, if this node is taken offline access to the system for the entire organisation would be compromised. To address this, the architecture is making use of the public cloud. Public cloud offerings provide for auto scaling and provide for replication. When implementing the proposed architecture, a public cloud provider and it's implementation of auto-scaling and replication would have to be investigated to avoid a single point of failure.

Section 4: System Scalability

At a high level, system scalability can be implemented by introducing more nodes. As an organisation grows and opens up more locations, the necessary infrastructure must be added, including the configuring of the new node's replication node. This added complexity does carry an inherent initial setup cost however it is this distributed design that allows the system to scale to very large organisations.

The API Gateway and discovery layer is a key area of system scalability due to it being a single point of access for the system for the organisation. Routing too many requests through this layer could potentially have a negative impact in terms of system performance. The scalability of the public cloud is the proposed solution to this. Automatic scaling, such as AWS Auto Scaling (Amazon, n.d.), provide the ability to monitor system performance and load, and deploy further resources to meet the demand. As the HRMS may only be accessed at certain periods of time, resources can scale up and down as necessary, reducing the costs while maintaining system performance.

Private clouds can be either on-premises or off-premises, or a combination of both. The proposed application allows for any combination of private clouds. To take full advantage of the benefits offered by cloud computing, my recommendation for an implementation of the proposed architecture would be a combination of on and off premises private cloud.

A HRMS is responsible for potentially sensitive employee and candidate data. Third party private cloud solutions may have different policies in regard to the ownership and governance of data hosted on their networks. The data may not be hosted in the same jurisdiction as the organisation, possibly posing ethical and legal implications (Atlam & Wills, 2020). It is therefore recommended that the data is hosted on a private cloud. This allows for greater control over the governance, access and ownership of the data but can increase the cost of scalability. For an organisation to scale using this architecture, they must purchase and manage their own storage and cloud. However, this increase in cost in qualified personnel to implement and maintain the infrastructure is offset by the greater security and privacy offered.

Hosting the application layer on a third party, private network such as offered by Azure (Azure, n.d.), would allow an organisation to leverage the scalability of cloud computing. Similar to the scalability used by the discovery and API Gateway layer, the system can increase resources required to meet demand. However, it must be noted, that separating the application layer from the data storage layer may introduce some latency to the system. Before implementing a solution, an organisation must assess the costs and benefits of on and off-premises private clouds.

Section 5: Authentication, Security and Privacy

Data governance, ownership, access, and security is a major concern for modern organisations. For global organisations operating in multiple jurisdictions, the architecture of a HRMS may have legal implications for the user data stored. For example, organisations based in the European Union (EU) must adhere to different laws (Altorbaq, Blix, & Sorman, 2018) than organisations based in the United States.

Organisations may adopt regulations required in one region and apply those policies across the entire organisation. This is commonly enacted to save costs of managing multiple policies across multiple regions. A common example is seen in what is known as

'The Brussels Effect' (Bradford, 2012), where organisations do not want to lose access to the EU market but do not want to spend additional capital implementing region specific policies. Due to the distribute nature of the proposed architecture, organisations have the flexibility of implementing region specific or organisation wide policies.

The storage of security of employee and candidate information is a core aspect of the proposed design. To maintain the best control over this data it is recommend that the storage is kept on an on-premises private cloud. This does require specialised staff with database administration and secure systems knowledge. This added cost allows regional centres to implement required security and access policies.

The architecture proposes each region maintaining a copy of its own data and processes, as well as that of a neighbouring region. The distribution of data can pose some additional discovery challenges; however, it does provide an inherent layer of security. The distributed nature of the data means that in order for an attacker to gain access to all data within an organisation, they must compromise 50% of the organisations nodes (Czajkowski, Fitzgerald, Foster, & Kesselman, 2001).

Authentication and authorisation systems are part of the proposed architecture. The authentication system is responsible for identification management, while the authorisation module is responsible for granting users access. These modules can be self-contained or they can interact with third-party offerings such as OAuth (OAuth, n.d.). The authorisation module acts as middleware between the API Gateway and the rest of the services controlling user access rights. There are several access layers required for the proposed HRMS, the auth packages inform the presentation layer as to what views to display to certain users, as well managing access to data. For example, HR staff would have access to various users data whereas external auditors are provided only with the access and data they require to perform audits.

Section 6: System Management

The management structure of an organisations HRMS grows as the organisation itself grows. Managing a large organisation presents several challenges in comparison to administrating a small organisation. The architecture laid out in figure 1 and figure 2 show that there are several requirements in the administration of infrastructure and the system.

To implement the proposed architecture each node requires infrastructure to provide on-premises storage at a minimum. To reduce latency and improve efficiency, it is recommended that the application layer is also deployed on the local private cloud. To implement this solution an organisation would require staff with networking, database administration and security skills. The architecture does allow for the application layer to be hosted on an off-premises cloud, however the cost savings in terms of specialist staff would be minimal as the same administration skill set is required for the data storage. The infrastructure for hosting the API Gateway and discovery layer is maintained by the third-party cloud provider, while the view layer is on the client machines.

The design of the HRMS allows for a large amount of management and administration tasks to be performed remotely (Makarova et al., 2019). Implementing policies, deploying updates, and configuring of tooling can all be done remotely. This allows an organisation to consolidate its main IT teams in a single location. Local IT teams will be required for certain tasks, however depending on nodes geographic locations in relation to each other, administrative teams could be strategically located to provide maximum coverage with fewer resources.

As the organisation scales and further nodes are added, a review of its administrative needs must be conducted. During the implementation phase, IT professionals would be required on location to install the required infrastructure. Once the system has been deployed on the node, system administration may be possible from a central or neighbouring node, or a permanent, local team may be required.

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