Maaz Saad

Professor Carolyn McGregor

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Cloud Computing Capacity Planning

Business Context Summary

Toronto Zoo opened its doors to the public in August 1974 after costing a staggering $22 million to complete construction and another $6 million to procure animals and plants (Toronto Zoo). The zoo employs roughly 300 full-time workers and another 300 part-time or seasonal workers (Toronto Zoo). The zoo is spread over 700 acres of land, is broken into seven zoogeographic regions, and plays host to more than a million visitors in a calendar year (Toronto Zoo). Most importantly, the zoo houses approximately 6,000 animals representing at least 500 different species (Toronto Zoo). The zoo is owned by the city of Toronto and operated on behalf of the municipality by a board of management comprised of four members of the Zoological Society of Toronto and five members appointed by Toronto City Council (Toronto Zoo).

And on that note, our organization has been hired by the board of management to prepare a report that can help them assess if it makes business sense to invest in a cloud computing platform that can potentially improve the quality of life of the animals, provide a better experience to visitors, and reduce operating costs. The goal of this project is to introduce the use of climatic sensors in the zoo with the hope that the data generated by these sensors will assist management in taking preemptive measures.

The board would like to reduce the need for veterinarians to perform expensive surgeries on animals through the introduction of measures across the zoo that can proactively pinpoint potential issues before they negatively impact the animals. Similarly, the board would also like visitors to have a more enjoyable experience and would like to increase the number of return visits. Additionally, by introducing a series of analytical mechanisms to the zoo's operational workflow, the management can improve efficiency, reduce waste, and provide a more nourishing habitat to its residents.

Big Data Sizing Estimates

According to the Toronto Zoo website, the zoo is home to over 500 different species (Toronto Zoo). For the purposes of our report, we are assuming that for the first phase of this project, we would like to install one sensor for each type of species inside their respective enclosures. The zoo has four pavilions, several indoor exhibits, greenhouses, administration and service buildings, two restaurants and snack bars, and a walking trail (Toronto Zoo). Based on this information, we have created the following estimate for the number of sensors that will be required for our project:

Location	Number of Sensors
Animals	500
African Pavilion	10
Americas Pavilion	10
Australasia Pavilion	10
Indo-Malaya Pavilion	10
Greenhouses Building	5
Administration Building	5
Services Building	5
Restaurants x 2	3
Snack Bars x 4	2
Walking Trail	10
Extras	20
Total	**590**

It goes without saying that these quantities are just preliminary estimates, and the exact number of units will change once our team visits the location in person and determines the size, width, depth, and height of the hallways, exhibits, and enclosures, etc.

As mentioned earlier, the type of sensors that we are installing at the zoo are climatic sensors that can provide real-time information via the internet. The sensors will provide temperature, precipitation, humidity, wind speed, and wind direction data. And the data will be recorded and transmitted to the servers every five seconds. The transmission of data will utilize Message Queuing Telemetry Transport (MQTT), which is ideal for lightweight data transmission with an unreliable internet connection and limited bandwidth resources (Paessler). MQTT is

predominantly used for machine-to-machine (M2M) communications or IoT types of connections, which is exactly our case (Paessler).

In order to estimate data usage by MQTT, we are basing our assumptions on a reference guide published by Telit in 2021. According to this guide, an MQTT connection uses approximately 15 bytes of data while publishing data from the sensor to the cloud (Telit). Based on this value, we have constructed the following table to get a fair sense of how much data will be generated per sensor and for the entire installation on a daily basis as well as annually.

Metrics	Data Usage
Data generated per sensor (MB)	0.0000143051147
Data generated per sensor (MB) * 5	0.0000715255737
# Of times data generated per day	17,280
Data generated per sensor per day (MB)	1.235961914
Total number of sensors	590
Data generated for all sensors per day (MB)	729.2175293
Data generated for all sensors - Annual (MB)	266,164.40
Data generated for all sensors - Annual (GB)	259.93

Minimum Database Storage Requirements

Since we will be generating multiple data points every 5 seconds, we will need to store them in a database that is able to record thousands of rows of data per day. For this reason and after careful consideration, our team has decided that Toronto Zoo should invest in Oracle Database, as Oracle DB is a top-performing database when it comes to analytics, availability, security, and scalability (Oracle DB). Oracle DB is a relational database and can exceed the performance of similar databases in terms of managing vital IoT workloads (Oracle DB).

Moving on to the installation of Oracle database, Oracle recommends that an organization install Oracle database home, which includes Oracle database binaries, trace files, etc., on Oracle ACFS or NTFS (Oracle HDS). To ensure the security of data, Oracle suggests that the files be stored on Oracle ASM if the organization is using Oracle ACFS (Oracle HDS). On the other hand, storing files directly on Oracle NTFS is a secure option as well (Oracle HDS).

Furthermore, 32 MB of space is needed to install the Java Runtime Environment (JRE) and Oracle Universal Installer in order to run the Oracle database components (Oracle HDS). For our purposes, we are assuming that Toronto Zoo is set up on the 64-bit version of Windows, and they will be storing data on NTFS (Oracle HDS). Since this is a pilot project, we recommend that Toronto Zoo start off with the starter database, which requires 720 MB of disk space (Oracle HDS). In addition to these storage spaces, the standard edition would require another 10.24 GB of space that includes storage provisions for temporary space, program files, oracle home, and data files (Oracle HDS). This brings the total amount of hard disk space required to install and run the Oracle database to roughly 11 GB.

Please note that these storage estimates do not include storage provisions for disk space, the space required to create a database, or the size of compressed files that are uncompressed on the hard drive (Oracle HDS).

Total Cloud Space Requirements

For good reason, cloud computing has become a buzzword in recent years. Migrating to the cloud helps organizations save on networking costs, storage costs, and computing costs (WhatIs). With cloud computing, the organization can modify the amount of money they spend to maintain their network on a monthly basis (WhatIs). Instead of purchasing a large amount of storage space on premises, they have the option to purchase more space as needed (WhatIs). Lastly, most cloud service providers offer competitive pricing and pricing plans due to competition in the market, and with enough clout, an organization can negotiate a deal that is in their best interest (WhatIs). And in the case of the Toronto Zoo, we are certain that, due to the sheer magnitude of this project, a personalized payment plan has a high probability.

We would recommend that Toronto Zoo employ the services of Google Cloud, as they have an excellent payment plan that requires users to pay only for what they use (WhatIs). As calculated in the previous two sections, the total space needed to install the database is 11 GB, and approximately 22 GB's worth of data is estimated to be generated every month from the climatic sensors. The database can be stored in cold storage as that data will not need to be retrieved, edited, or modified on a daily basis. Utilizing Google Cloud's cold storage or archive storage is cheaper than standard storage, where our sensors' data will be stored (WhatIs). As a result, Toronto Zoo would require 33 GB of cloud storage space on a monthly basis.

Cloud Utilization Costs – Database

This table breaks down the cost of operating and maintaining the Oracle database and storing the data points that are generated every five seconds. We would like to reiterate that these estimates are based on the assumption that every data point uses 15 bytes of storage space. Additionally, the monthly costs are extracted for the region of Toronto from Google Cloud's homepage, and these costs are expected to increase as of April 1, 2023 (Google Cloud).

Storage Type	Cost	Space (GB)	Total Cost - Monthly	Total Cost - Annual
Oracle DB - Archive Storage (per GB per Month) - Toronto	$ 0.0025	11	$ 0.03	$ 0.33
Climatic Sensors - Standard Storage (per GB per Month) -Toronto	$ 0.0230	22	$ 0.51	$ 6.07
Total Cost			**$ 0.53**	**$ 6.40**

Conclusion

The purpose of this report was to create a cloud computing capacity plan for the Toronto Zoo. The zoo is re-rejuvenating operations by introducing the use of climatic sensors to better understand the physical needs of the animals through data analytics and also improve their tourist engagement. We have nominated Oracle DB, which the zoo can select as its primary database. Additionally, we have also estimated the storage space needed for the database and the data generated by the climate sensors. Our advice to the zoo is to purchase space on Google Cloud to host their database and store the data generated from the climatic sensors, as it would be more cost-effective than hosting the data on physical servers at the zoo or elsewhere.

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