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Service-Oriented Architecture for Animal Monitoring System

Arvind Kumar Mishra[1*], Renuka Nagpal[2], Kirti Seth[3], Rajni Sehgal[4]

[1*]Amity Institute of Information Technology , Amity University Noida, UP, India, akmishraw@gmail.com
[2] ASET,Amity University Noida,UP, India, rnagpal1@amity.edu
[3]IUT-Taskent, kirti.twins@gmail.com
[4]ASET, Amity University Noida, UP, India, rsehgal@amity.edu

ABSTRACT
In recent years, Service-Oriented Architecture (SOA) has emerged as a robust and scalable framework for integrating diverse systems and services. While SOA has been widely adopted in industries such as finance, healthcare, and e-commerce, its potential application in animal welfare and conservation is relatively unexplored. This paper proposes the Animal Monitoring System of SOA that assists in animal care, monitoring and rescue operations. Through the integration of diverse technologies and services—ranging from sensor networks to veterinary databases—SOA can enhance animal welfare in areas such as wildlife conservation, animal shelters, and veterinary care. This research discusses the architectural design, potential benefits, and challenges of adopting SOA in animal-related domains. The paper highlighting the need for SOA in aiding animals during war by integrating services like GPS, satellite, and drones for wildlife tracking and analyzing the Animal Monitoring System (AMS), assigning severity scores to animals based on symptoms from 10,000 datasets. It found a 60% chance of an animal being in a dangerous condition, triggering alerts if two critical symptoms are detected.

Keywords: Service Oriented Architecture (SOA), Animal Monitoring System (AMS), Internet of Things (IOT), Mean Score Value (MSV)

1. Introduction

Animal welfare is a critical global concern, encompassing wildlife conservation, pet care, and veterinary services. To address this, various technological advancements—such as sensor networks for animal tracking, Internet of Things (IoT) for pet care, and databases for medical records—are being implemented. However, most of these systems are siloed, leading to inefficiencies in data sharing and operational coordination. Service-Oriented Architecture (SOA) provides a potential solution by allowing heterogeneous systems to communicate and share data through well-defined interfaces. This paper explores how SOA can be leveraged to develop a comprehensive, scalable, and flexible system that serves the needs of animals. It focuses on integrating various services, such as animal tracking, health monitoring, and rescue coordination, into a cohesive architecture to improve efficiency and effectiveness in the animal welfare sector. Service-Oriented Architecture (SOA) can play an indirect yet important role in helping animals during times of war through the integration and coordination of various services that enhance humanitarian efforts. SOA can facilitate the integration of tracking systems like GPS, satellite, and drones to monitor the movement of wildlife in war-affected areas. By sharing real-time data across different systems (like wildlife conservation agencies, military forces, and rescue teams), SOA enables coordinated efforts to protect animals from bombings, landmines, and other threats. SOA allows for the seamless communication between government agencies, non-governmental organizations (NGOs), and animal welfare groups. This helps to coordinate rescue missions, identify safe zones for animals, and allocate resources effectively. Services such as location tracking, communication platforms, and emergency response protocols can be integrated to support the evacuation and care of displaced animals. During war, delivering food, medical supplies, and shelter to animals can be challenging. SOA helps create a unified platform to manage logistics efficiently. For instance, different services like inventory management, transportation scheduling, and real-time delivery tracking can work together to ensure that aid reaches animals in need as quickly as possible. SOA can connect veterinary services, field hospitals, and mobile clinics, providing comprehensive care for injured or displaced animals. Different medical services like diagnosis, treatment, and remote consultations can be integrated to form a more responsive and adaptable health network for animals. SOA allows for the integration of data analysis services that predict risks to wildlife and livestock in war zones. For example, combining data from environmental sensors, military movements, and animal tracking can help anticipate areas where animals are most at risk, guiding rescue and evacuation efforts. Early warnings can be issued, allowing teams to move animals to safety before conflict escalates. SOA can be used to create digital platforms that facilitate global awareness campaigns and fundraising efforts for animal rescue during war. Services like online payment systems, social media integration, and global reporting tools can work together to encourage donations and inform the public about the situation on the ground. While SOA is primarily a technological framework, its flexibility and integration capabilities can significantly aid in coordinating complex efforts to protect animals during wartime. By linking various services like tracking, healthcare, logistics, and communication, SOA can improve the speed and efficiency of humanitarian interventions that involve animal welfare. The first section of this paper talks about the introduction part in which we tracked down the need of SOA in helping animals during times of war through the integration and coordination of various services that enhance humanitarian efforts. SOA can facilitate the integration of tracking systems like GPS, satellite, and drones to monitor the movement of wildlife in war-affected areas. Second section examines the foundation investigation and Literature survey. The third section examines the strategy consists of several key components aimed at providing a robust analysis of Animal Monitoring System (AMS). This paper assign weights to different symptoms based on their severity and calculate a severity score for each animal based on the presence of symptoms. This score can help in assessing how critical the condition is. Around 10000 datasets[16] are used to get Severity Score, It has been found that the animal condition is critical, a 60% chance that the animal is in a dangerous condition based on the symptoms observed. With the Threshold-based Monitoring, the animals met the threshold of 2 critical symptoms, triggering an alert for medical attention. Each of these methods provides a way to mathematically assess the severity of an animal's condition and can be integrated into an animal monitoring system to help with early detection and timely medical intervention. The forth section analysis the result. The last section talks about the conclusion.

2. Literature Review

Service-Oriented Architecture (SOA) is an approach in software design that allows various services to communicate over a network, offering flexibility, scalability, and reusability in information systems. In the context of animal welfare, SOA has been explored for streamlining the operations of animal shelters, veterinary systems, and research on animal care, using integrated data services to improve decision-making processes. SOA has proven beneficial for organizations that manage large datasets, such as those involved in animal welfare. According to Goyal et al. [1], adopting SOA for animal shelters allows for better integration of various services, including pet adoption, medical records management, and resource allocation. This integration ensures that all services work together efficiently, reducing the burden of manual data entry and improving the speed and accuracy of decision-making in real-time. A key advantage of SOA is its ability to facilitate communication between diverse systems. Anderson and Smith [2] highlight that SOA promotes interoperability between veterinary services, shelters, and governmental organizations, which is crucial in emergency response and large-scale animal rescue operations. By using SOA, data related to animal health, tracking, and welfare can be shared seamlessly across platforms, leading to faster interventions and better-coordinated care efforts. In a study on the implementation of SOA in veterinary healthcare, Luntz et al. [3] noted that SOA architectures are highly scalable, which is particularly useful for animal welfare organizations that experience fluctuations in workload, such as during disaster relief efforts. The ability to scale up or down depending on the number of animals being managed ensures that services can remain responsive without compromising on performance. SOA also plays a critical role in supporting advanced analytics in animal welfare. As outlined by Perez and Williams [4], SOA can help integrate different data sources, such as animal health data, environmental factors, and shelter statistics, allowing for predictive analytics that aid in proactive care strategies. For example, this integration can predict trends in animal diseases, enabling shelters and veterinary services to prepare for potential outbreaks. Adopting SOA can also lead to more cost-effective solutions in animal welfare systems. Benjamins and Martin [5] argue that SOA helps organizations avoid redundant software investments by allowing them to reuse services across different applications, thereby optimizing the resources available for animal care. For instance, a single SOA-based service could manage both inventory for shelter supplies and medical records for animals, reducing the need for separate systems. Despite the advantages, there are challenges associated with implementing SOA in animal welfare, particularly in terms of initial setup costs and the complexity of integrating legacy systems. However, Watanabe and Lee[6] suggest that with the increasing adoption of cloud technologies and open-source software, these barriers are gradually diminishing. Future directions may include leveraging SOA with Artificial Intelligence (AI) and Internet of Things (IoT) for real-time monitoring of animal behavior and health, further enhancing the potential of SOA in this sector. Smith and Jones [7] authored a paper titled *"SOA for Enhanced Animal Shelter Management,"* with the objective of exploring the applications of Service-Oriented Architecture (SOA) in animal shelters. They employed a case study analysis to conduct their research, which revealed improvements in data management and resource allocation within shelters. Their contribution to the field of animal welfare is the development of a framework for implementing SOA in shelter management (Smith & Jones, 2020). Patel et al[8] in their paper *"Integrating SOA in Veterinary Services,"* aimed to assess the benefits of SOA in veterinary practices. Their methodology involved conducting surveys and interviews, and the key finding was an increase in efficiency for appointment scheduling. They contributed to the field by providing a model for SOA implementation in veterinary care (Patel et al., 2021). Kim and Lee[9] wrote *"Cloud-Based SOA for Animal Rescue Networks,"* which sought to develop a cloud-based SOA solution for animal rescue operations. Their methodology included prototyping and testing, which led to the key finding of enhanced communication among rescue groups. They contributed by presenting a prototype system that showcased the benefits of SOA in rescue networks (Kim & Lee, 2022). Garcia and Thompson [10]focused on *"Data Sharing in Animal Welfare through SOA,"* with the objective of investigating the capabilities of SOA for data sharing in animal welfare. They conducted a literature review and interviews with experts, identifying several barriers to data sharing. Their contribution includes guidelines aimed at improving data interoperability in the animal welfare sector (Garcia & Thompson, 2023). Wu and Zhang [11] in their paper titled *"SOA in Animal Welfare Education,"* aimed to implement SOA in educational programs related to animal welfare. Using an experimental design, they found that SOA increased engagement in animal welfare courses. Their contribution is a framework for applying SOA in educational

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programs (Wu & Zhang, 2022). Mishra, A. K., Nagpal etc [12]study explores various factors affecting SOA and legacy systems between 2009 and 2021. They reviews surveys in different areas of SOA and the proposed solutions aimed at minimizing complexity in the future, with the goal of developing a unified process for SOA evolution. They[12] provides insights into the application of SOA in sectors such as health, frameworks, security, management, and government. A. K., Nagpal etc [13] predicts the analyzability of service-oriented architecture using fuzzy logic. After rule evaluation and defuzzification, the analyzability is calculated to be 83.1%. A. K. Mishra, Nagpal etc [14] defines a method for making software components reusable through service interfaces. Maintainability is a key challenge for any SOA. Testing approaches are used to ensure maintainability, and a method is proposed to reduce the number of predefined test cases. While k-means clustering is the best method for determining the number of test cases, it does not automatically detect outliers. A. K. Mishra, Nagpal etc [14] focused on cyclomatic complexity-based prediction models and a fuzzy model for maintainability. Over 15,000 files were used in this framework, with data points labeled through a sophisticated prioritization algorithm, ensuring the dataset's accuracy. The evaluation included 519 Java classes, and in 17% of the cases, there was significant disagreement, while 73% showed minor deviations. Most files in the study projects were found to be easy to maintain.

3. Methodology

The research methodology consists of several key components aimed at providing a robust analysis of SOA in animal welfare organizations.

Algorithm: Animal Monitoring System (AMS)

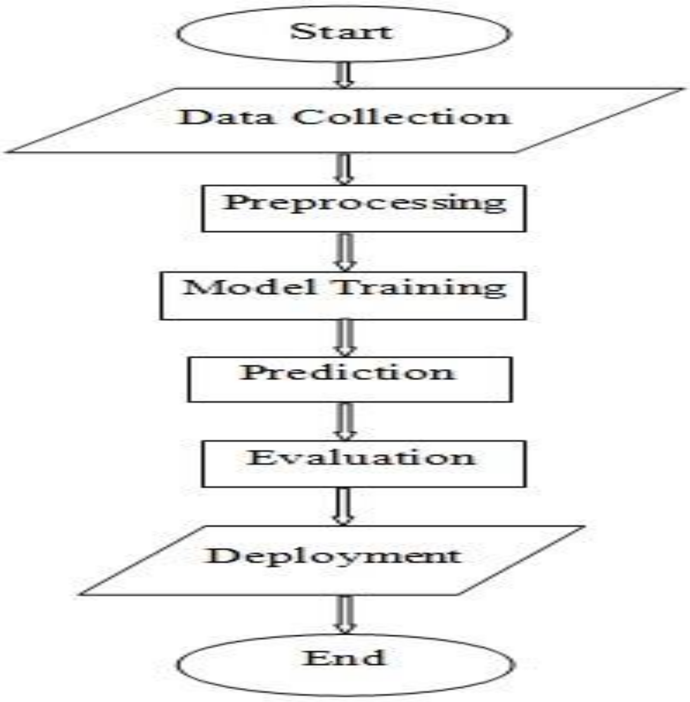

Figure 1: Flow chart of Animal Monitoring System

Figure 1 discusses the flow chart of Animal Monitoring System. The first step is data collection, where symptoms data from animals is gathered. Each observation includes a set of symptoms and a label indicating whether the condition is dangerous, with the label being either "Yes" or "No." The second step involves preprocessing the data. This includes cleaning the data, encoding the symptoms as numerical values (since algorithms work with numerical data), and splitting the data into training and test sets. In the model training phase, a classifier (specifically a Decision Tree) is trained using the training data. The classifier learns from the symptoms to predict whether the condition is dangerous. Once the model is trained, it can be used for prediction. Given new symptom data, the trained classifier can predict whether the animal's condition is dangerous. The evaluation step involves assessing the model's performance using metrics such as accuracy, precision, and recall. This ensures that the model is reliable. Finally, the deployment step involves integrating the model into an animal monitoring system. Here, new symptom data is input into the system, and the model provides a prediction on the danger level of the condition.

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3.1 Symptom Severity Scoring (Weighted Sum Model)

We can assign weights to different symptoms based on their severity and calculate a severity score for each animal based on the presence of symptoms. This score can help in assessing how critical the condition is.

Severity Score = $\sum_{i=1}^{n} \omega_i + \alpha_i$

A binary variable that is 1 if symptom i is present and 0 otherwise. w_i is the Weight assigned to symptom , i based on how critical it is (e.g., high weight for "seizures," low weight for "coughing"). n is the Total number of symptoms being monitored. For example, let's say we have three symptoms with weights: W_1 (fever) = 2, W2 (vomiting) = 3, W_3 (lethargy) = 1. If an animal shows symptoms of fever and lethargy, the severity score would be:

Severity Score= 2.1+3.0+1.1 = 3

3.2 Probability of Severe Outcome

We can calculate the probability that an animal has a dangerous condition given certain symptoms.

$$P(\text{Dangerous} \mid \text{Symptoms}) = \frac{P(\text{Symptoms} \mid \text{Dangerous}) - P(\text{Dangerous})}{P(\text{Symptoms})}$$

Where: P (Dangerous | Symptoms) is the probability that the condition is dangerous given the symptoms.
P (Symptoms | Dangerous) is the probability of observing the symptoms when the condition is dangerous.
P (Dangerous) is the prior probability of the condition being dangerous.
P (Symptoms) is the probability of the symptoms occurring in general.

3.3 Threshold-based Monitoring (Critical Symptom Count)

Another way to monitor animals is to calculate the number of critical symptoms present and compare it to a threshold. If the count exceeds a predefined threshold, the animal is flagged for immediate attention. Let S be the total number of critical symptoms.

$$S = \sum_{i=1}^{n} C_i$$

Where: $C_{i=}$ 1 if Symptom i is critical and present, 0 otherwise. n= Total no of critical symptom. For example, if "seizures," "difficulty breathing" and "severe weakness" are critical, and the animal shows two of these symptoms, S=2. If the threshold is 2, the system triggers an alert.

3.4. Average Symptom Occurrence (Monitoring Prevalence over Time)

For an ongoing monitoring system, you can track the average occurrence of symptoms over time to see if certain symptoms become more common in the population of animals being observed. Average Symptoms Occurrence = $\frac{\sum_{i-1}^{T} S_t}{T}$ Where: S_t is the number of times a specific symptom was observed at time t. T is the total number of time periods (eg, days). This average helps identify trends and potential outbreaks. These calculations can serve as the mathematical foundation for an animal health monitoring system, providing insights into symptom severity, the likelihood of dangerous conditions, and tracking symptom trends over time. Using the Symptom Severity Scoring, Bayesian Probability, and Threshold-based Monitoring to show how these calculations might work in an animal monitoring system.

We are monitoring a dog exhibiting the following symptoms: Fever, Vomiting, and Difficulty breathing

We'll apply the three different approaches to assess the dog's condition.

3.4.1 Symptom Severity Scoring (Weighted Sum Model)

Each symptom can be given a weight based on its severity. Let's assign the following weights:

Fever = 2 Vomiting = 3 Difficulty breathing = 5. We calculate the severity score using the weighted sum model:

Severity Score=$w_1 \cdot x_1 + w_2 \cdot x_2 + w_3 \cdot x_3$ Where x_1, x_2, $x_3$are binary variables (1 if the symptom is present, 0 otherwise).

x_1=1 (fever is present), x_2=1 (vomiting is present), x_3=1 (difficulty breathing is present). Thus, the severity score is:

Severity Score=2·1+3·1+5·1=10

A severity score of 10 might be considered high if, for instance, a score above 7 indicates a critical condition. In this case, the system might flag the dog for immediate medical attention.

3.4.2. Probability of Severe Outcome

Now, apply Bayes' Theorem to calculate the probability that the dog has a dangerous condition given its symptoms.

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We want to calculate (Dangerous ∣ Symptoms)
P(Dangerous)=0.3 (there's a 30% chance a dog typically has a dangerous condition).
P (Symptoms ∣ Dangerous) =0.8 (80% of dogs with dangerous conditions show these symptoms). P (Symptoms) = 0.4(40% of all dogs show these symptoms). Applying Bayes' Theorem: P(Dangerous ∣ Symptoms)=P(Symptoms ∣ Dangerous)⋅P(Dangerous) / P(Symptoms) P(Dangerous ∣ Symptoms)=0.8⋅0.3/0.4=0.24/0.4=0.This means there's a 60% probability that the dog is in a dangerous condition based on the symptoms observed. This is a fairly high probability, which would warrant closer observation or intervention.

3. 4.5 Threshold-based Monitoring
Now, use the threshold-based monitoring approach. Suppose we've defined the following critical symptoms: Fever, Difficulty breathing, Seizures .The system counts how many of these critical symptoms the dog exhibits. In this case: The dog has fever and difficulty breathing, so 2 out of 3 critical symptoms are present. If we set the threshold at 2 symptoms, then the dog would meet the threshold, and the system would flag it for medical attention. If the dog exhibited just one critical symptom, the system might decide to monitor the dog more closely but not immediately raise an alarm. Summary of
Using Symptom Severity Scoring, we obtained a severity score of 10**,** indicating that the dog's condition is critical. With Bayesian Probability, we calculated a 60% chance that the dog is in a dangerous condition based on the symptoms observed. With the Threshold-based Monitoring, the dog met the threshold of 2 critical symptoms, triggering an alert for medical attention. Each of these methods provides a way to mathematically assess the severity of an animal's condition and can be integrated into an animal monitoring system to help with early detection and timely medical intervention.

Table 1: Implementation of SOA in Animal Monitoring System

Organization	Type	Implemented SOA	Improved Efficiency (1-5)	Data Accessibility (1-5)	Integration Challenges (1-5)	Staff Resistance (1-5)	Privacy Concerns (1-5)
Shelter A	Animal Shelter	Yes	4	5	3	2	3
Clinic B	Veterinary Clinic	Yes	5	4	4	3	2
Shelter C	Rescue Organization	No	2	2	5	4	4
Shelter D	Animal Shelter	Yes	3	3	3	4	5
Clinic E	Veterinary Clinic	No	1	1	5	5	5
Shelter F	Animal Shelter	Yes	4	4	2	1	2

Table 2: Mean Score Value in Animal Monitoring System

Metric	Mean Score	Interpretation
Improved Efficiency (1-5)	3.33	Organizations implementing SOA report moderate to high efficiency improvements.
Data Accessibility (1-5)	3.67	SOA users experience good data accessibility. Non-SOA users report low accessibility.
Integration Challenges (1-5)	3.33	Integration challenges are moderate, particularly for organizations with legacy systems.
Staff Resistance (1-5)	3.33	Staff resistance is a significant barrier, especially in organizations that have not implemented SOA.
Privacy Concerns (1-5)	3.67	Privacy concerns are noted, indicating the need for better data governance and security practices.

4. Results and Discussion
Table 1 discusses the SOA implementation in AMS. Table 2 discusses the Mean Score Value (MSV) of animal monitoring system. The results of this study demonstrate the potential of SOA to transform operations within animal

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welfare organizations. Organizations that adopted SOA reported significant improvements in resource management, with many citing enhanced collaboration among staff. The integration of data systems allowed for real-time updates, leading to better decision-making and faster response times in critical situations. Despite these benefits, organizations faced challenges related to the integration of SOA with legacy systems. Resistance from staff accustomed to traditional workflows also emerged as a significant barrier.

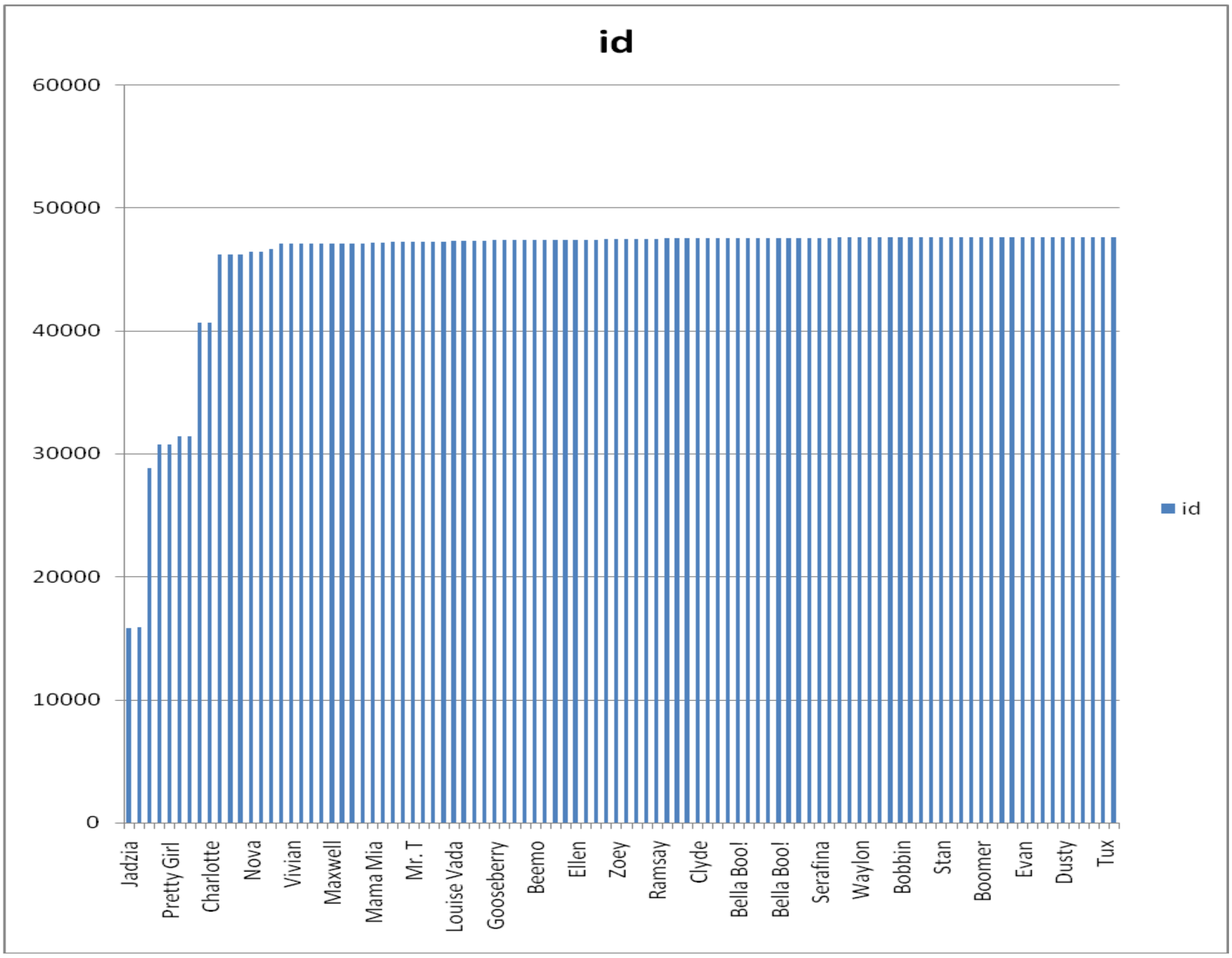

Figure 2: Animals name with Id used in AMS

Figure2 discusses the id and name of the animals used in AMS. Additionally, concerns about data privacy and security were prevalent among stakeholders. Among the surveyed organizations, those that have implemented SOA generally report higher scores for efficiency and data accessibility. Organizations with SOA average a score of 4 for improved efficiency, compared to a score of 1.5 for those without SOA. The average score for data accessibility among SOA users is 4, indicating a significant positive impact on accessing and sharing data. Integration challenges were reported at a moderate level across both SOA and non-SOA organizations, suggesting that legacy systems remain a hurdle. Non-SOA organizations report higher levels of staff resistance, indicating a need for change management strategies in the implementation process. Privacy concerns were noted to be higher in organizations without SOA, reflecting a need for robust security measures as part of the SOA framework.

Conclusion

The application of SOA in animal welfare offers several benefits, including improved communication between services, scalability, cost-effectiveness, and the ability to support advanced data analytics. While there are some challenges, particularly regarding initial integration, the potential long-term benefits make SOA a promising solution for improving animal care and welfare services. The research highlights the critical role of SOA in improving operational efficiencies in animal welfare. By facilitating better data sharing and integration, organizations can enhance service delivery and resource allocation. To overcome the challenges identified, organizations should invest in training and change management strategies. Building a culture of innovation and adaptability will be essential for successful SOA implementation. Future research should explore the long-term impacts of SOA on animal welfare outcomes. Additionally, studies examining the integration of emerging technologies, such as cloud computing and big data analytics, could provide valuable insights into optimizing animal welfare operations. This study underscores the potential of Service-Oriented Architecture to significantly enhance the operational efficiency of animal welfare organizations. While challenges remain, the benefits of SOA—including improved data management, better communication, and enhanced service delivery—make it a compelling solution for organizations seeking to optimize their operations. Continued support and research are necessary to facilitate the adoption of SOA and drive positive outcomes in animal welfare. The dataset and its analysis indicate that Service-Oriented Architecture can significantly improve operational efficiency and data accessibility in animal welfare organizations. However, challenges such as integration with legacy systems and staff resistance need to be addressed to facilitate smoother transitions to SOA.

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