Big Data Analytic and IoT for Water Resources

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Abstract: Water is an increasingly scarce commodity. This life-preserving resource is an integral component of all industries, from agribusiness to power generation. New technologies like Big Data can enable businesses, communities, and people to overcome this crucial issue for humanity. However, the digital transformation of water management can only attain significant success if designed and executed efficiently. Indeed, Analytics and Big Data could prove decisive in our fight against the loss of water resources. Combined with the Internet of Things, Big Data analytics technologies could help us optimize resource consumption, and reduce their losses. This paper, will investigate the role of these new techniques and their provision of qualitative water sources to facilitate and improve the average human life. What appropriate architecture can we implement to solve our water scarcity issues compared to existing digital architectures?

1 INTRODUCTION

Water resources are the starting point for life in all the species that live on our planet. Most living things need freshwater, but only 0.3% of the water on Earth is potable. The water demand has increased due to population growth due to economic development. At the same time, in various regions, they suffer flood and drought, leading to mismanagement of water resources. Furthermore, climate change has a significant impact on water systems. This causes major changes in water resources due to its direct effects on hydrological processes such as evaporation, humidity, and precipitation. The combination of growth in the water demand, the hydrological gap, and the climate pushed resource managers and decision-makers to seek strategies for the effective management of water resources. To achieve this (Moumen, A, 2016)benefit, it is necessary to increase the Information and Communication Technologies capacity (ICT) to help solve many types of problems that water management currently faces. In retrospect, the development of technology and the social economy has expanded the field of data services for water resources. Moreover, the development and application of RS, GIS, GPS, IoT (Internet of Things), and other modern technologies for collecting information that considers the spatial and temporal types of data, generate a solid increase in the volume and data types stored in clusters, or other technologies like cloud servers.

According to Mocanu et al. (2013), there are several challenges related to the development of ICT for water management today:

- The amount of data grows progressively, so they need methods to manage large volumes of data;
- The data comes from numerous legacy systems that collect and process information, such as that related to tributaries, for example. As a result, decision-makers often base their decisions on outdated applications.
- The geographical area for the analysis is wide.
- The data is of a different type, which analyzes the same more complex.

2 METHODOLOGY

The literature review defines a process and reporting structure to classify and identify research and results

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that were published for a given topic (in our case, big data Analytics and Internet of Things in the field of natural resources)(Elhassan et al., 2020). The objective of the literature review is the classification, thematic analysis, and identification of the main forums of publication. The process followed in this study is illustrated in the following figure, which bases itself on a survey of 96 articles in the various databases subsequently saved in Zotero and analyzed via NVIVO:

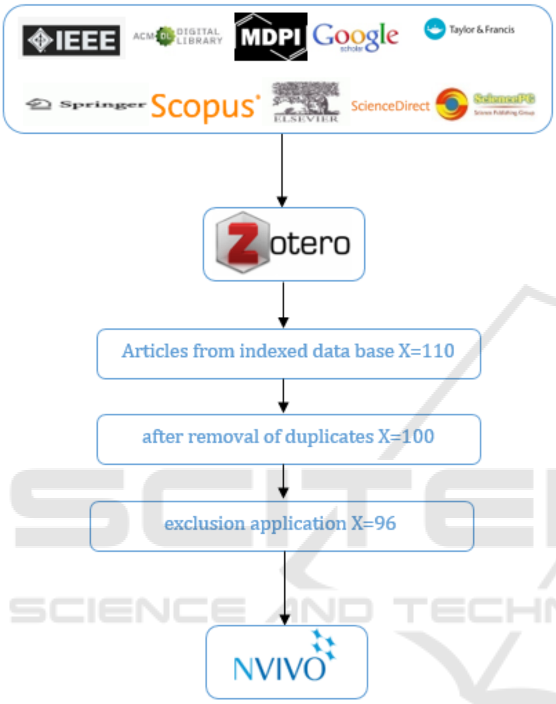

Figure 1: Literature review processes.

In this paper we will focus on the articles that have reached the stage of implementing a big data analytical architecture in the field of natural resource management.

3 EXISTENT BDA & IOT ARCHITECTURES FRAMEWORK

According to the literature review process described above, we have arrived at a set of existing architectures in the field of water resources. At first, we will make a comparison of the different architectures proposed and, in the end, we will present our architecture that encompasses the different existing elements so that it will be implementable in reality:

- Big Data Analytics for Water Resources Sustainability Evaluation : The author (Zhao and An, 2019)of this paper tries to show us the structure of their architecture based on four layers described as follows:

  - Material layer
  - Communication layer
  - Middleware layer
  - Application layer

For the processing of a large mass of data, the authors carried out a parallel analysis which that decomposes sub-similar tasks.

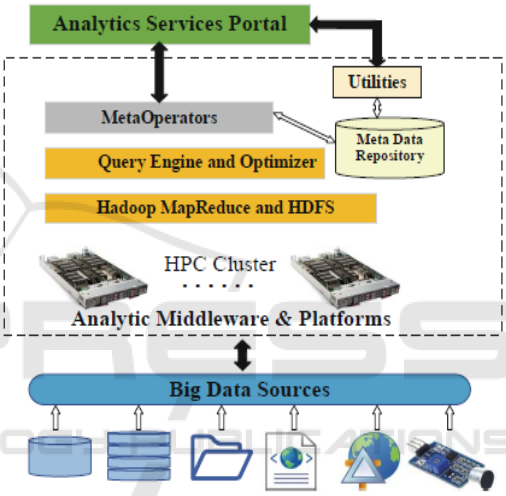

Figure 2: Big Data Analytics for Water Resources Sustainability Evaluation(Zhao and An, 2019) proposed by Yinghui Zhao &al.

- An IoT-based system for water resources monitoring and management (Xiaocong et al., 2015): The authors propose an IoT-based solution to support decision-making using a water resources management and monitoring system. The architecture consists of four layers as a suite:

  - Perception Layer
  - Network Layer
  - Middleware Layer
  - Application Layer

The efficiency of connected objects and their rapid development capabilities, along with their high level of security and availability, are the main reasons why the government in Beijing launched an IoT project in 2021 to monitor large cities.

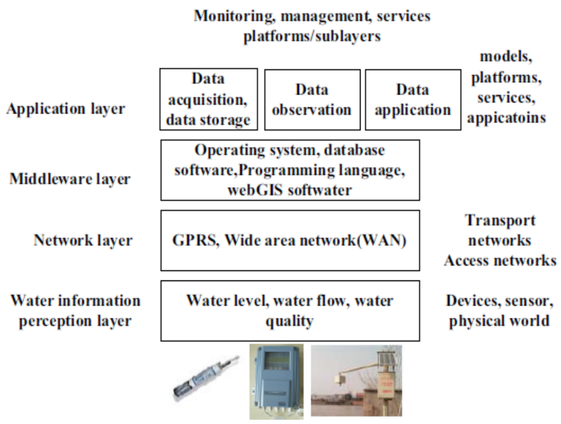

Figure 3: An IoT-based system for water resources monitoring and management (Xiaocong et al., 2015) proposed by Mo Xiaocong &al.

- A secure cloud-based solution for real-time monitoring and management of Internet of underwater things (IOUT)(Gopinath et al., 2019) : The upgraded IOUT-based architecture is a replacement of its predecessor, which works using base stations with monitoring centers. In turn, the upgraded version works with the following nodes:

  - Sensor nodes
  - Receptor nodes
  - Cloud nodes: cloud-based monitoring center

All three nodes use a cluster-based topology so that the communications between the three are based on the cluster heads.

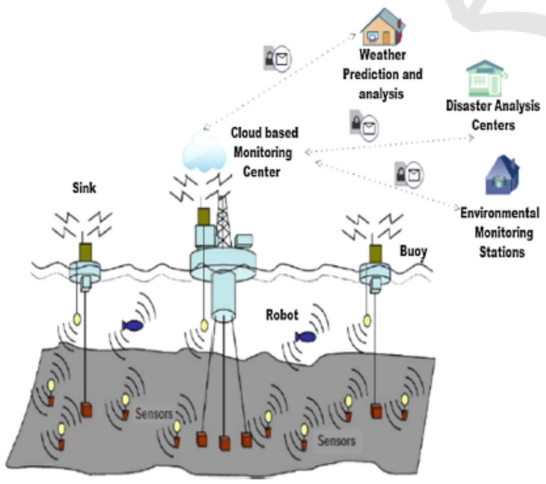

Figure 4: A secure cloud-based solution for real-time monitoring and management of Internet of underwater things (IOUT)(Gopinath et al., 2019) proposed by M. P. Gopinath &al.

- Big Data Open Platform for Water Resources Management(Chalh et al., 2015) : in this work, the authors create a platform to solve and discuss the problems of water resources offered for a massive volume of the collection, analyzed and displayed data, to explore the heterogeneity of data resulting from various sources, including semi-structured ,structured and unstructured, also to forbid and, or avoid a catastrophic event concerning floods and, or droughts, thanks to water infrastructure designed for purposes. This work focuses particularly on the hypsometric focus developed in J2EE. This tool is a decision tool that allows users to compare the effects of different management scenarios, both current and future, with the possibility to preserve the natural and environment resources.

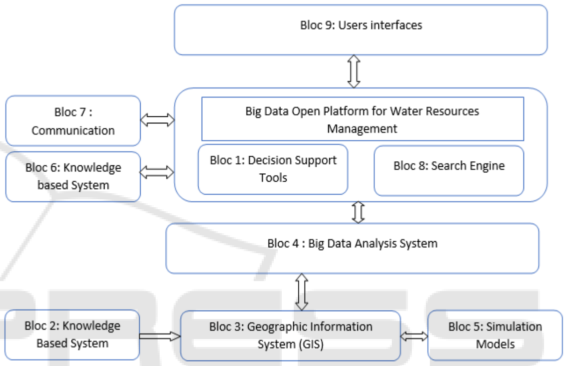

Figure 5: Big Data Open Platform for Water Resources Management(Chalh et al., 2015) proposed by Ridouane Chalh &al.

- A Framework for Processing Water Resources Big Data and Application (Ai and Yue, 2014): The limitations of traditional methods include efficiency, storage, real-time processing, and rapid analysis of current water resources data. These limitations are the leading causes for the proposal of this architecture.

The author's design architecture with four layers:

  - Data acquisition layer
  - Resources organization layer
  - Data analysis layer
  - Application service layer

The authors try to present their applications for analyzing big data in this process and present the framework of application and processing of this water resources data.

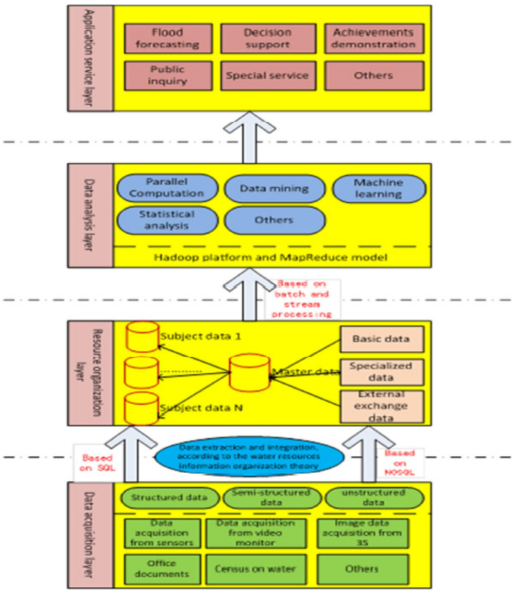

Figure 6: A Framework for Processing Water Resources Big Data and Application (Ai and Yue, 2014) proposed by Ping Ai &al.

▪ Big Data analytics and IoT in Operation safety management in Under Water Management (Nie et al., 2020): Mastering the use and conservation of water has become one of the most critical priorities of water providers. To do this, the authors of this paper try to propose an architecture based on connected objects and big data analytics to solve their water conservation concerns in urban areas where it is complicated to keep the recording of water consumption.

The main components of this architecture are based on five:

- ➢ Sensors …
- ➢ Cloud
- ➢ Internet & Wifi
- ➢ Mike Urban
- ➢ SCADA (Supervisory controller and data acquirement)

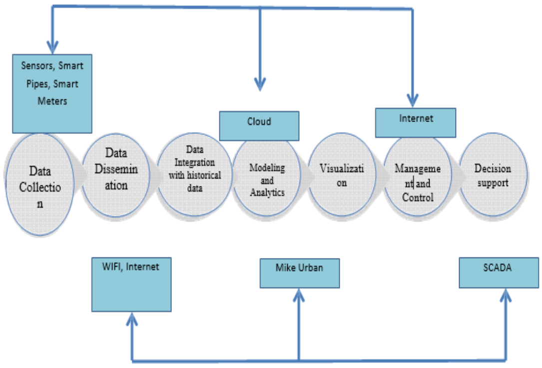

Figure 7: Big Data analytics and IoT in Operation safety management in Under Water Management(Nie et al., 2020) proposed by Xiangtian Nie &al.

4 DISCUSSION

Studies on Big Data architectures, designed to manage water resources of a locality, present a vision of the research available in this field, allow the formulation of new research papers, and determine the most and least exploited topics in the area.

In this part, we make a higher-level analysis and comparison of six existing architecture. Since the latter have different views or perspectives on how architecture models are represented, reliable comparison frameworks need to be characterized by fundamental elements: objectives, inputs and results.

The following table provide a more detailed comparison of the different architectures proposed. At first, we detail the objectives of each architecture and its reasons to be presented. Then we present the various inputs and checkmarks of each architecture. Finally, we check their implementation and results.

Table 1: Comparison of proposed architectures.

Architectures	objectives	inputs	layers	results	Implemented Y/N
(Zhao and An, 2019)	They intend to create a prototype for assessing the sustainability of regional water resources using big data from regional economic and social growth.	▪ data from different resources such as: ▪ IOT ▪ Internet ▪ Folder ▪ Database	▪ Hardware layer ▪ Communication layer ▪ Middleware layer ▪ Application layer	An implemented architecture that allows the assessment of the sustainability of regional water resources in the city of zhoushan	yes
(Xiaocong et al., 2015)	Propose a system based on the internet of things (IoT) for water resources monitoring and management	▪ IOT	▪ Equipment perception layer ▪ Information transmission layer ▪ Data application layer	Proposed architecture based on IOT for water resources management and monitoring	No
(Gopinath et al., 2019)	Energy-aware and secure communication strategies are required in the IoUT environment.	▪ IOT	▪ Data capture (using sensor, robot,Sink …) ▪ Data monitoring ▪ Data analysis & prediction	The suggested architecture is more secure and private than the current system.	yes
(Chalh et al., 2015)	to solve and discuss water resources problems involving a large volume of collected, analyzed, and visualized data, to analyze the heterogeneity of data resulting from various sources, including structured, unstructured, and semi-structured data, and to prevent and/or avoid a catastrophic event related to floods and/or droughts using hydraulic infrastructures designed for such purposesor strategic planning.	▪ GIS data	▪ Decision Support Tools ▪ Knowledge-Based System ▪ Geographic Information System (GIS) ▪ Big Data Analysis System ▪ Simulation Models ▪ Computation and Processing ▪ Communication System ▪ Search Engine Users Interfaces	Propose o prototype of big data that can offer possibility for water resources management	No
(Ai and Yue, 2014)	framework for processing water resources big data, to process and analyze modern water resources data for real-time and rapid	▪ Structured and unstructured data ▪ Sensors ▪ Video monitor ▪ Office documents ▪ others	▪ Data acquisition layer ▪ Resource organization layer ▪ Data analysis layer ▪ Application service layer	the framework for processing water resources big data and application provides some reference for big data processing in the field of water conservancy industry.	No
(Nie et al., 2020)	Based on IoT and Big Data Analytics, a Supervisory Controller and Data Acquisition (SCADA) approach for sustainable water management in the smart city.	▪ Internet ▪ Sensors ▪ Smart Pipes ▪ Smart Meters	▪ Data collection ▪ Data dissemination ▪ Data integration ▪ Modeling & analytics ▪ Visualisation ▪ Management & control ▪ Decision support	The implementation intends to produce better levels of sustainable water supply by proactively controlling water usage by both companies and customers.	Yes

5 PROPOSED ARCHITECTURE

We base ourselves on the comparative table between the different architectures proposed; we study their limits at the level of implementation. We present our architecture prototype that tries to respond to the various difficulties encountered.

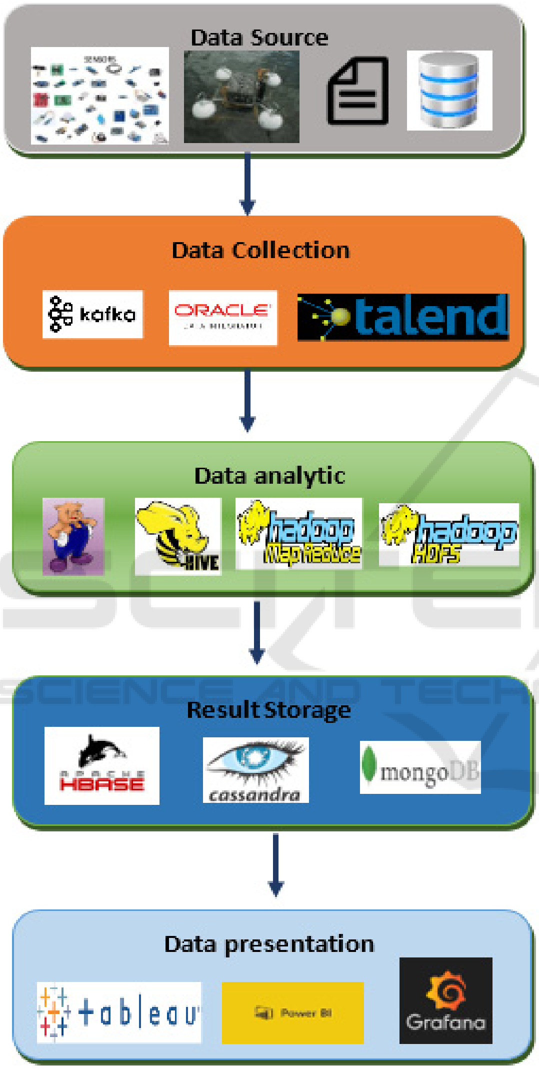

Figure 8: Proposed architecture.

6 CONCLUSION

In this paper, we compared and analyzed six digital architectural frameworks proposed for water management, using their different layers and modules. As a result of this study, we proposed our architecture prototype that combines all layers and modules and can also be implemented and tested quickly.

Looking forward, we believe that in the next decade, new and innovative development methods will be adopted within the context of water resource management. These will incorporate and encompass the challenges of requirements gathering, data validation, model-driven development, and the list goes on.

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