Dam Monitoring and Alerting System in Real Time via Integrated IoT Platforms Using LoRaWAN Technology.

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***Abstract*—Dam Monitoring and control in remote areas is one of the most difficult things in times of flood. The LPWAN technologies have paved ways to connect and control devices using the LoRaWAN (Long Range Wide Area Network) technologies. Internet of Things (IoT) connects a variety of platforms and software designed to augment IoT device functionality in various areas. These platforms functions effectively in specific tasks within their domains. This study explores the integration of automation platforms with key elements like "Things Network" for LoRaWAN connectivity and data monitoring, "Data Cake" for downlink command, IFTTT for notification and "ThingSpeak" for data visualization. This also represents different methods for connecting these automation-based IoT platforms and studies their efficiency and performance in dam monitoring and flood alerting system. This study will bring in understanding of IoT technologies and platforms, unveiling their potential applications in Dam monitoring that are in remote areas.**

Keywords*—*Dam monitoring, flood alerting system, IFTTT, ThingSpeak, The Things Network, Internet of Things, Real time Data Monitoring, Data Cake, Integrated IoT Platforms, LoRaWAN.

I. INTRODUCTION

The quickly growing Internet of Things (IoT) comprises a wide variety of emerging technologies for applications, frequently conforming to precise communication standards while embracing whole-system architectures. Developing, connecting, and managing IoT solutions include the creation and management of networked equipment and processes that gather, share, and analyze data. This includes hardware and software expansion, network configuration, analyzing information, and device maintenance.

The goal is to promote efficient and automated operations, data-driven decision-making, and increased control across multiple applications in order to monitor, maintain, alert and notify the operations of a Dam. This study comprehensively investigates the structure of the physical layer, communication layer, and the network layer, that together works in order to alert the Dam's critical condition during a catastrophic condition. The design of IoT platforms, as well as the integration of several platforms in processing real-time data, will guarantee faster evacuation and control accesses, since LoRaWAN speeds up data transmission across numerous cloud platforms and informs users when data values increase significantly.

A. LPWAN & LoRaWAN

A class of wireless communication technologies known as LPWAN is intended to provide low-power, long-range communication. Connecting devices that need extended battery lives—typically lasting several years or even a decade—without regular replacements is the main objective of LPWAN. For Internet of Things (IoT) and Machine-to-Machine (M2M)[3] applications where data transmission has to travel a significant distance yet happens occasionally, LPWAN solutions are perfect. LPWAN is a broad term for low-power, wide-area networking technologies,[1] whereas LoRaWAN is a particular protocol within the LPWAN family that uses LoRa modulation for long-range communication with minimal power consumption. Other LPWAN solutions include Sigfox and NB-IoT (Narrowband IoT), which employ various modulation techniques and technology to achieve the same aim of long-range, low-power IoT communication.[2]

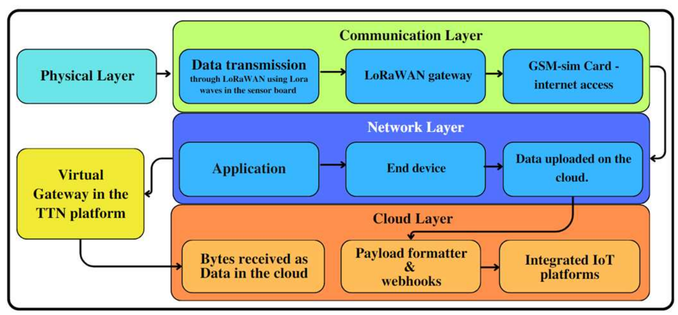

Fig.1.LoRaWAN-based transit of sensor data to the cloud.

LoRaWAN devices have over 10km of coverage in rural areas and 3km of range in dense urban areas. The LoRa has an SNR between -20dB and +10dB.The throughput is around 250 (bps) at the greatest range and 22 (kbps) at the shortest range. The RSSI is minimum - 120dbm; if RSSI = -30dBm, the signal is strong; if RSSI = -120dBm, the signal is weak. [4] Figure 1 depicts how LoRaWAN is utilized to transmit sensor data to the cloud for the purpose of study. LoRa devices, with their interoperability with the Arduino IDE, have found uses in alerting systems, real time monitoring, and more.

B. The Things Network (TTN) and Integrated platforms.

The Things Network provides LoRaWAN network servers. TTN's backend solutions manage IoT data routing among

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devices and apps. Gateways connect radio protocols and the Internet in an ideal IoT network. In other circumstances, devices support the IP stack, whereas gateways only route packets to the Internet. Non-IP protocols, such as LoRaWAN, require processing and routing before messages can be sent to an application. The Things Network connects gateways and apps, managing routing and processing activities. [2]

This study uses integrated platforms such as The Things Network, ThingSpeak, IFTTT, and Data Cake. These platforms offer automation capabilities and connect apps and services to create custom workflows. IoT devices, such as sensors, can trigger actions and send notifications via SMS using IFTTT. The transmitted data can be visualized and trigger actions can be sent by the ThingSpeak platform, and Data cake provides templates with built-in payload encoders and decoders, as well as visualization and downlink integrations, which will be particularly beneficial in real-time monitoring, access, and device management for LoRaWAN devices.

II. LITERATURE SURVEY

The Internet of Things as a whole and LoRaWAN are widely recognized for their real-time monitoring and ability to notify catastrophic events in remote areas. This is especially useful during emergencies for transmitting data far and wide. The purpose is to analyze these networks and to gather insights about the real-time performance of the IoT and LoRaWAN protocols across various scenarios. Table 1 analyses IoT and LoRaWAN capabilities for real-time monitoring.

TABLE I. KEY FINDINGDS ON IOT AND LORAWAN CAPABILITIES.

Author and year	**Title**	**Key Findings**	**Merits of the System**
S. S. Siddula et al. 2018 [5]	Water Level Monitoring and Management of Dams using IoT	IoT is able to transmit information about water levels to a central command center.	Data transmission through IoT devices and the ability to monitor multiple environmental factors.
M. Bajare et al. 2018 [6]	Preventive Maintenance System for Dam Using IOT and Cloud	IoT is used to ensure dams remain in working and safe condition, maintaining the dam.	The preventive maintenance system consists of different sensors are used to inspect different components of the dam.
Pasika *et al.* 2020 [7]	Smart water quality monitoring system with cost-effective using IoT.	Multiple IoT enabled platforms can be used for different purposes.	The sensors are used to measure various parameters of the surrounding atmosphere.
Almone, et al. 2020 [8]	Evaluation of LoRa WAN network performance for a water level sensing and monitoring scenario in Mosul Dam.	LoRaWAN is an ideal choice for implementing dam monitoring systems in remote areas.	LoRa network's performance can convert traditional monitoring to smart monitoring as well as the capability of one LoRa gateway to run up to thousand end devices.
SRG.Tamilarasi et al. 2024 [9]	Monitoring Sensor Data in Real Time via Integrated IoT Platforms Using LoRaWAN Technology	The integration of IoT platforms with key elements for LoRaWAN connectivity and for data visualization.	Real-time monitoring, Continuous surveillance, and Early warning capabilities.

a The Keyfindings show the Merits of of IoT and LoRaWAN.*

From the table it is evident that dams can be monitoring using IoT and LoRaWAN with integrated technological aspects will also help in continuous monitoring for remote areas.

Detention Dams

A detention dam is a structure designed to collect surface runoff and stream water flow and control water flow in regions below the dam. Detention dams are widely utilized to mitigate flood damage or to control channel flow rate. Detention dams can also be built to restore groundwater and capture silt. Detention dams are one of three types of dams: storage, diversion, and detention dams.[5]

Early warning systems can be put around the dam to identify and notify to any potential seismic activity or meteorological occurrences that could harm the dam. This approach gives timely alerts of possible threats, although it may not provide direct measurements of seismic activity or meteorological conditions.[4]

III. METHODOLOGY

From the literature it is understood that using IoT it is possible to control and monitor a dam. However dams in remote areas cannot warn a larger crowd, in order to solve this problem the study proposes an idea and a prototype for early warning system with the downlink and Uplink using LoRaWAN technology. Figure 2 shows the overall workflow of the proposed Dam monitoring system.

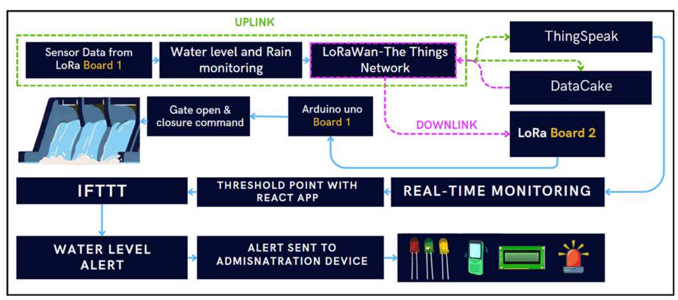

Fig.2. Workflow of the Dam monitoring system.

The LoRa board is attached with the sensors to monitor the water level of the dam and the amount of rain. This data is sent to the cloud using LoRaWAN, using the cloud TTN the data is then sent to ThingSpeak for real time visualization and from here the data is then sent to IFTTT for notification to alert the administration. On the other hand the data from TTN is sent to Data cake and is attached to another board with LoRa, once the threshold is reached the data cake reads the data and send the downlink signals to the MCU with LEDs and Buzzer to alert the opening and closing of the dam automatically. This procedure is explained in detail below.

C. LoRa Board 1.

All the Sensors for the set methodology are connected to the LoRa board. This sensing set up includes sensors like Ultrasonic senor for sensing the distance of the accumulated water beside the measuring scale. Rain sensor for sensing and alerting the amount of rain over a particular period of time. The

LoRa board is basically an Arduino Uno board attached with a sense hat that has the LoRa shield embedded in it. This shield is capable of transmitting LoRa signal using the monopole antenna, the data packets then gets queued according to the programmed sensors using Arduino IDE and reaches the LoRaWAN outdoor gateway. LoRaWAN is the wide area network that carries the long range data packets over a network. [10]

D. *The Things Network.*

The Things Network is a cloud platform specifically made for LoRaWAN communication. It has two major access points, i) The application layer ii) the Gateway layer. Both of these elements form the console of the cloud. The console is a basic platform given to any registered member of the Things Network cloud. The application layer is where the user can have multiple applications with multiple number of devices connected to it. Each application is capable of creating 50 end devices and these end devices have their specific device EUI and app EUI through which the LoRaWAN can be accessed in the hardware programming of the sensors along with its boards. The gateway part of the console on the other hand has specific ways of connecting the indoor gateway or the outdoor gateway with its gateway EUI. Within the gateway console the tracking of data packets and the status of the gateway can be monitored and the gateway can also be used by multiple user using the collaborator access given by admin of the TTN console.

The Application layer inside The Things Network has webhook access. Many platforms can be connected using this feature. The end device inside the application layer has an inbuilt feature in which the received data packets can be changed into human readable data using the payload formatter using the JSON language. Using these two features of this layer the data can be sent to ThingSpeak platform for further monitoring. The same procedure is done with Data Cake IoT platform for uplink and downlink receiving procedures.

E. *The ThingSpeak.*

Once the data reaches the ThingSpeak channel, the data is ready to be monitored and visualized. The ThingSpeak has two features that mainly help in real time monitoring and notifying the users in real time. The http feature and Reach app in the channel play a crucial role. The HTTP feature connects the JSON data from ThingSpeak. The React works alongside with the http feature and sends the triggered event via HTTP and this message reaches the integrated IFTTT platform. [11]

F. *IFTTT and Notification.*

The triggered message reaches this platform. The IFTTT works in applets and whenever the applet reached the triggered message it send SMS through the registered phone number or email to the receipt admin device, there by alerting people in faraway places. [12]

G. *Data Cake and LoRa Board 2.*

Using the payload formatter and webhook feature of the application layer the data reaches DataCake platform as well. The data cake has a unique feature of sending downlink message using payload formatter triggers. This triggered message then goes to the TTN and another LoRa board 2 receives the downlink messages. [13]

H. *LoRa Board 2 and the reflex mechanism.*

To understand the mechanism a working prototype model is explained .The LoRa Board 2 is connected with another Arduino Uno board which is programmed in a way to receive these messages and display it on an LCD display for the prototype module and also connects to another set of LEDs for alerting using three different LED bulbs with different color codes – Green with a safer color, Yellow is the caution indicating color and Red is warning and the color indicating the gate opening color and Buzzer. The servo motor is attached to the gate of the dam to demonstrate the working of the prototype, when the caution data reached the board the servo motor attached to the gate will open the gate of the dam to half and when it reaches the warning data the servo motor opens the full gate for the water to flow and in order to not break the dam during such catastrophic situations. The results are discussed in the following section. [14]

IV. RESULTS

The paper outlines a methodology for a functional IoT system which is LoRaWAN-based linked to different IoT integration platforms. It effectually handles the collected data, monitors the received data, visualizes the data, sends notifications in real time, takes back the downlink messages and sends it and also has a reflex mechanism to the received data. All these results are summarized in the subsequent sections.

A. *The LoRaWAN set-up.*

As mentioned the sensors are connected to the LoRa board 1 and the data is sent to TTN using the Arduino IDE for hardware programming and LoRaWAN for transmission of the data.

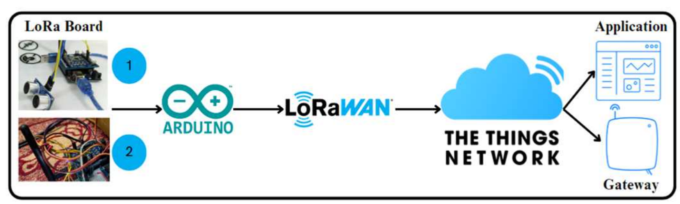

Fig.3.Data from LoRa boards 1 and 2 to TTN platform.

Figure 3 shows the flow of data from LoRa boards 1 and 2 to TTN platform. The LoRa board 2 is also connected to TTN using the same set up, but is programmed for receiving downlink messages from TTN.

B. *The Integration of cloud platforms.*

The Data reaches the TTN and using the webhook the data is sent to DataCake for downlink processing and to ThingSpeak for uplink process. Once the uplink process is over, the data triggered events goes to IFTTT for further notification to the users in Real time. Figure 4 show the figurative flow of data between each cloud platform. The data between TTN and DataCake is bidirectional, facilitating quick and easy uplink and downlink effectively in real time. The key advantage of this study focused on how to handle the downlink data and proceed further for an effective and holistic functioning of the model. And this integration paved ways for this study to successful. [15]

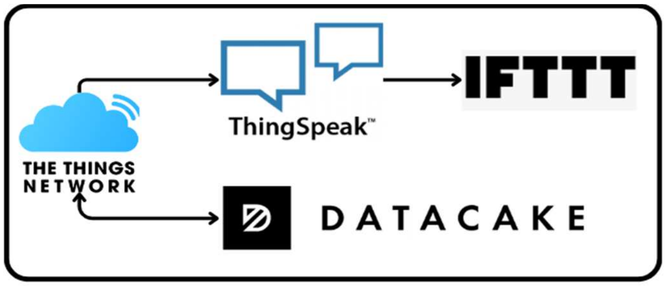

Fig.4. Flow of data between each cloud platform.

C. The Receiving node.

This node gets data command from DataCake via TTN through LoRaWAN. Once the data packet reaches the LoRa board 2, it send messages to the Uno board which is connected to the LEDs and the servo motor.

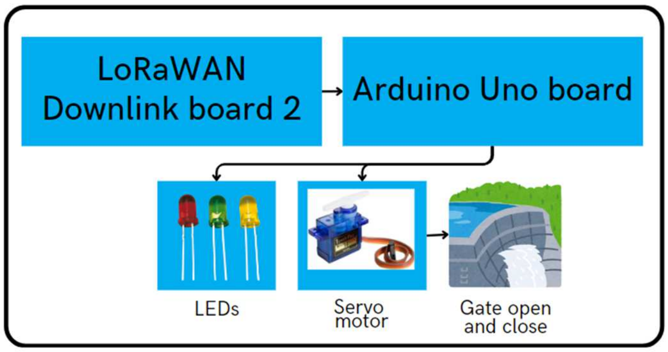

Fig.5. is the flow of data from LoRa board 2 to the servo motor.

The servo motor attached to the dam gate acts according to the command received. Figure 5 is the flow of data from LoRa board 2 to the servo motor.

D. The prototype.

In figure 6 the setup of LoRa board 1 is shown, where the Arduino Lora board is attached to the sensors and, where the ultrasonic sensor is attached below the breadboard and the rain sensor is attached to the upper side of the breadboard.

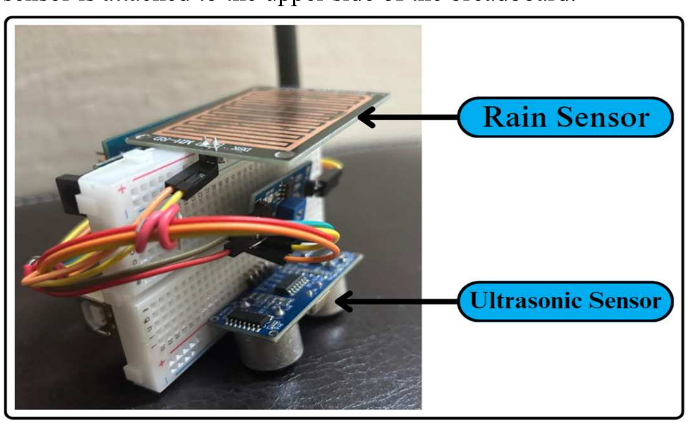

Fig.6. the sensing node of the prototype - LoRa Board 1.

The ultrasonic senor will measure the water length inside the bucket and the rain sensor will calculate the amount of rain received as mentioned in figure 7. This will then start the process of sending data to the cloud for further processing of the received data.

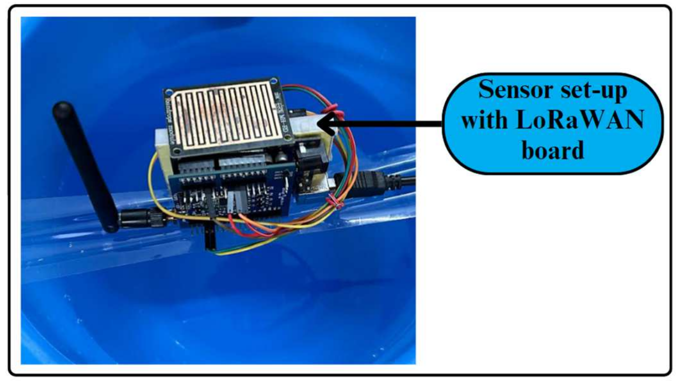

Fig.7. the sensing node placed over the prototype to check the water level.

Using these metrics, the data is processed in the cloud and the resultant mechanism will happen in the overall set up accordingly as mentioned in Figure 8. The model includes three main stages the safe stage, the caution stage opens the half of the gate and the warning stage where the full dam gate opens.

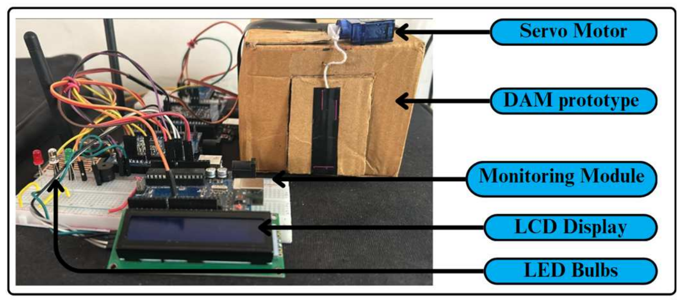

Fig.8. Dam monitoring using LoRaWAN prototype.

When the rain sensed and the level of water rises up to a safe level a green LED bulb is lit and the LCD display shows the value of the percentage level in order to indicate the level as shown in in Figure 9(a).

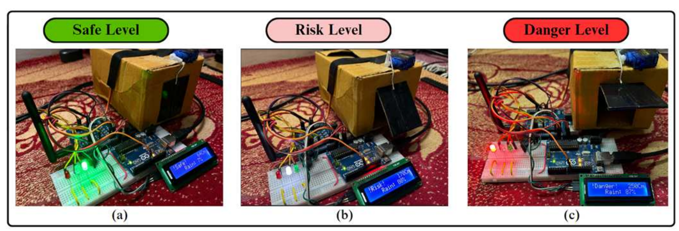

Fig.9. The working prototype. (a) safe level, (b) risk level, (c) danger level.

When the rain sensed and the level of water rises to a risky level a white LED bulb is lit and the LCD display shows the value of the percentage level in order to indicate the level as shown in Figure 9 (b). When the rain sensed and the level of water rises to a risky level a white LED bulb is lit and the LCD display shows the value of the percentage level in order to indicate the level as shown in Figure 9 (c).

These procedures are done in the physical layer of communication, on the other hand the data is collected by the cloud and the processed data in plotted as a graph in the ThingSpeak channel for assessing the metrics and for future research and also for real time notifications to the user. In the figure 10 (a), (b), (c) safe levels of the monitored dam set-up are plotted in the graph.

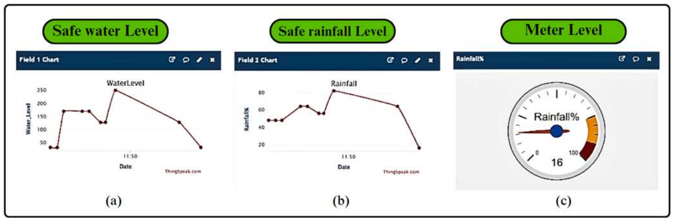

Fig.10. ThingSpeak Channel safe level, (a)water level, (b)rainfall level, and (c) rain gauge level.

These levels indicate the water level, the rainfall level and the rain gauge level as safe. In this case the notification will not be sent to the user, however the LCD display will display the levels. Here in the case of the prototype the level of alerting of the water is 25 cm and the level of rainfall is 16%.

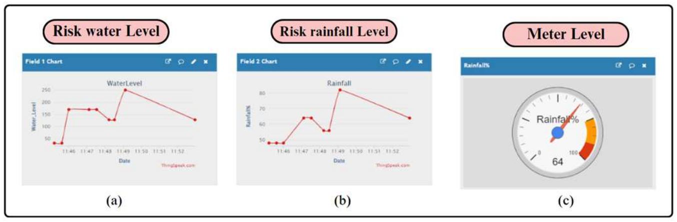

Fig.11. ThingSpeak Channel risk level, (a)water level, (b)rainfall level, and (c) rain gauge level.

In the figure 11 (a), (b), (c) risk levels of the monitored dam set-up are plotted in the graph. These levels indicate the water level, the rainfall level and the rain gauge level as risky. In this case the notification will be sent to the user, the LCD display will display the levels, but the buzzer remains silent. Here in the case of the prototype the level of alerting of the water is 120 cm and the level of rainfall is 64%.

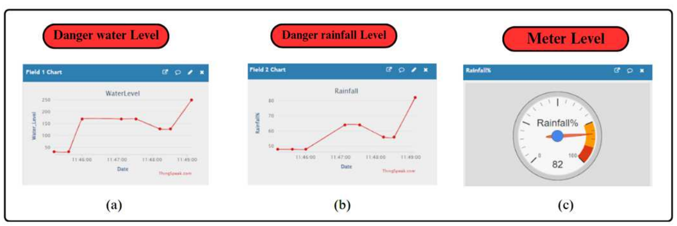

Fig.12. ThingSpeak Channel danger level, (a)water level, (b)rainfall level, and (c) rain gauge level.

In the figure 12 (a), (b), (c) danger levels of the monitored dam set-up are plotted in the graph. These levels indicate the water level, the rainfall level and the rain gauge level as danger. In this case the notification will be sent to the user, the LCD display will display the levels and the buzzer will also start alerting. Here in the case of the prototype the level of alerting of the water is 250 cm and the level of rainfall is 82%.

The data cake also receives these data, the downlink is headed by the data cake platform, once the risk and danger levels are reached the gates are opened accordingly.

V. CONCLUSION

This article describes a thorough strategy to implementing a functioning LoRaWAN-based IoT Dam monitoring system that integrates different IoT platforms and downlink protocols for dam gate opening and shutting, as well as early warning user messages. Data is collected using an Arduino Uno board coupled to a LoRa-shield sensing hat, as well as information from an ultrasonic and rain sensor. This information is then sent to The Things Network's cloud interface, which establishes connections with ThingSpeak via API and access keys. These connections provide a cohesive system that quickly manages data gathering, processing, and rapid user notifications. This highlights the versatility and usability of various IoT integration platforms in real-time applications and user interactions. The future scope of this study would be to compare the prototype to real-time working models, adjust to real-world challenges, and work toward building a fully functional model. The key advantage of this model is that it demonstrates real-time downlink methods.

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