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AN IOT-BUILT PEDIATRIC CRADLE WITH AN ANDROID APP FOR INFANT CARE USING MACHINE LEARNING

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Abstract—The growth of mobile phone usage and the accessibility of high-speed Internet connections contribute to the growth of the Internet's user base. Using portable devices to track the conduct of their kids and other people's infants by working parents is a serious issue. A "smart cradle" through video has been proposed in light of these findings. When a baby cries, this cradle swings into action automatically. Suppose the baby cries for a period. In that case, the tool will vibrate and emit text communication to the person's mobile phone, notifying them that the child cannot be supported in the cradle and that the newborn necessitates human support owing to the moist bedding. An infant can play with a toy that rotates by itself in this cradle, reducing the likelihood that it will wail nonstop. In recent years, mothers who work outside the home have become more prevalent. As a result, most families rely on their grandparents or childcare facilities to watch their kids. In order to provide newborns with high-quality care when their parents are absent, we upgraded our system and added a new algorithm. It is because working parents find it challenging to keep tabs on their kids' development under normal circumstances, let alone in emergencies.

Keywords—Nodes, Smart Cradle, Arduino atmega328A microprocessor, IOT, SDS

I. INTRODUCTION

Nodes are the vital nodes of microcontrollers. The Adafruit MQTT server will process the sensor data the controller board has received daily. With the ambient temperature, humidity, and sound level, sensors track the infant's heart rate, respiration rate, oxygen levels, and oxygen saturation. NX Siemens' software was used to develop the cradle prototype. The construction's structure is made of scarlet meranti wood, which is exceptionally striking. Thanks to technology, the newborn cradle swings internally, propelled by a motor as soon as the baby starts to cry. Parents can watch their kids even when they are not home using an external web camera. This network has undergone rigorous testing to guarantee its dependability and security.

In order to provide remote medical help, the notion of telemedicine blends physiology, biomedical technology, and telecommunications. Insufficient medical staff, the size of some populations, and the need for uncomfortable travel times are just a few of the problems that telemedicine may be able to solve. Telemedicine has several clear advantages, but because it requires expensive equipment, it needs to be more utilised. Routine phone conversations and video conferences in telemedicine are ineffective because the doctor needs to be sure of the patient's physiological condition. A sophisticated system with several sensors is needed to offer the physician a feeling of the child's virtual environment and expected physiological parameters. Low-cost, transportable telemedicine devices are being developed using recent developments in embedded technology and the Internet of Things. The sensors nevertheless maintain the same precision and dependability despite using low-power technology. Using effective computer language approaches, sensor signal analysis and visualization are performed [2]. The system performs continuous parameter checks to display measurements and has a graphical user interface. The suggested method only requires a little training, in contrast to the vast majority of medical devices that are now available. The suggested method is very trustworthy and can identify various physiological cues. One measure uses noninvasive blood pressure to calculate pulse transit time, heart rate, skin temperature, and pulse rate. Moreover, they show the blood's oxygen content.

Life cannot advance farther at the current pace. Most parents with jobs find balancing their work and childcare obligations challenging. It may be difficult for parents to keep a careful eye on their kids after lengthy workdays. It is frequently impossible to physically move the cradle to quiet the baby if it is crying. If they have a babysitter, they will put the child's safety first. As a result, a solution that involves both parents and kids is required [3]. We are aiding these parents in carrying out their parental duties by giving them cradle equipment.

The cradle will automatically rock back and forth when a baby cries. If the baby screams for a long time, the device will notify the parent's smartphone and sound an alarm. An alert is sent, and an alarm is set off if the mattress gets wet. The baby must always be in a safe area with help readily available. Thus, the second alert is crucial. Data can be transferred from a remote computer to a Smartphone with the right app [4]. Parents may monitor their child's health from anywhere at any time.

Sales of Android smartphones are expected to reach a record high this year. As a result, Android was used in the system's development.

Sensors can produce electrical impulses after detecting physical quantities. Sensors are becoming an essential part of daily life in the modern world, where almost everyone can access some electronic device [5]. Several types of sensor data are frequently inputs for embedded systems. Over the years, various sensor types have been developed, each with a unique output, materials, principles, measuring procedures, and methodologies [6]. By transforming electrical signals into mechanical signals, actuators can move and control the systems to which they are connected [7]. For instance, a microprocessor-generated electrical signal causes the actuator to

fill and empty the air cuff in an electronic sphygmomanometer [8]. The Internet of Things (IoT)-connected actuators can be used in various offshore applications, including robots that move limbs with motion control and home appliances that control water pumps [9].

Figure 1 shows the essential element. Not all transducers in embedded systems are equal; some transducers lack the necessary data converters for direct digital data transfer. The processing unit's integrated analogue-to-digital data converter can be interfaced with analogue sensor data [10]. It is suggested that the signal be promptly digitalised using an external ADC to maximise noise immunity when there is a significant distance between the sensor and the controller [11]. Specific actuators can only process analogue signals because they lack internal data converters. The connection of an actuator requires analogue-to-digital signal converters because a microcontroller can only transfer digital signals [12]. Although microcontrollers have internal memory, it is usually insufficient, making it necessary to use external memory devices that can interact with the microcontroller to enhance system performance. High-end applications require bootable read-only storage (ROM), and embedded systems frequently need operating systems (ROM). Nonvolatile data on embedded systems may be booted from and saved on solid-state drives, CD-ROMs, hard disks, flash drives, and pen drives with an OS [13]. Multiple access memory (RAM) modules may be added easily to boost processing performance. For dynamic synchronous RAM modules, single-inline, dual-inline, and tiny dual-inline packages are all accessible.

The most recent advancement in cutting-edge technology is a telemedicine application solution that is relatively affordable. Based on a photoplethysmogram, the oxygen saturation sensor eliminates the need for routine calibration [14] by keeping track of the sensor's changing temperature and current operational parameters. The photoplethysmogram and ECG signals are recorded simultaneously to precisely calculate the pulse transit time (PTT) [15]. Using an arm cuff to take the patient's blood pressure is unnecessary—a very effective graphical user interface (GUI) for presenting specific medical signals and parameters [16]. The portable device has a built-in camera that lets the doctor check the patient's well-being from a distance.

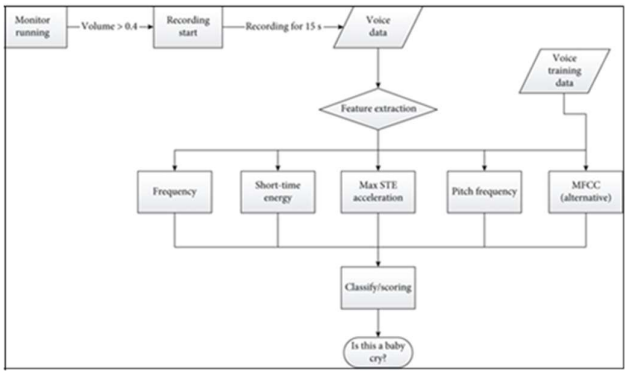

Fig. 1. Basic Block Diagram

II. INTERDEPENDENT WORK

The technique, which provides a health tracking system, which gathers raw data from sensing devices and transfers it to a microprocessor for analysis, is powered by an Android smartphone. The information is transmitted through Bluetooth to an Android phone. Many modern health monitoring systems use a GSM to send an alert to the phone.

The first fully automatic rocking cradle with safety features was made by [17]. The spring-loaded motor oscillated, giving the impression that the mother was rocking the cradle. Traditional cribs and contemporary electric cribs are connected in some way. A computerised device is in charge of managing the action [18]. The timer will determine how long the machine will rock the baby when the microphone picks up the baby's cries. A technique for identifying a baby's screams is created and tested. Pulse generator circuits quickly create the pulse signal instead of amplifiers that amplify a sound source. A signal processor receives this pulse signal which keeps working with it. The baby's cries are the recognition circuit's output. Below is an illustration of an automated baby rocker with a noise sensor. Before being transferred to A preamplifier, it boosts the sound signal before sending it to the Arduino atmega328A microprocessor, which controls the baby seat's rocking motion. The mother's attention is diverted by multicoloured LED lights that flash [20]. Based on sensor data, [17] presents a technique for changing the rocking motion of a baby's crib—a third international gathering on automation, control, and computing.

In 2017, a newborn's health was evaluated using three pressure sensors. Three sensors were positioned on the bassinet's base: two on the left and right and one in the centre [21]. According to Joseph et al. research, the nation's medical facilities have established that India's urban and rural healthcare systems are interrelated. Because they reside in rural settings, almost 700 million Indians lack access to high-quality healthcare [22]. More than 80 per cent of the population in India receives access to medical professionals for their diseases. The researcher advocates virtually moving urban professionals to rural locations to improve medical standards. Video conferencing [23], which also allows global teleconsultation, is one of the most effective tools for remote medical consultation. The doctor and patient can speak digitally via telemedicine, and the doctor can watch the patient from numerous areas. It minimises the time a doctor or patient requires from a rural place to a metropolitan city. Telemedicine system components include record-keeping, analysis, and visualisation [24].

Virtual medical personnel visits to intensive care units improve distant medical treatment [25]. Providing adequate medical care may be difficult in highly industrialised countries with vast populations. People in the rural parts of these nations commonly die prematurely due to a lack of access to prompt medical care [26]. A system must be established and continuously accessible to monitor a remote individual's health and relay that information to the appropriate parties.

This study built a distributed network system with a few sensors for measuring health parameters to facilitate remote medical treatment [27]. The system incorporates a teleservice centre that provides remote support as necessary by analysing patient data.

According to the system's architecture, patients do not have to travel far to visit medical facilities, which minimises travel time and healthcare costs [28]. They can provide cutting-edge support to even the most remote medical facilities due to astounding data collection and communication technology advancements. As a result of its multi-sensor integration and remote monitoring capabilities, the system helps treat a range of diseases. ECG, blood pressure gauge, scale, and heart rate monitor [29] are the essential components of this system. This study analyses sensor data using a smartphone and a Data Acquisition Unit (DAU) [30]. [31] developed an Android-based telemedicine system to provide medical care to areas with limited access to doctors and hospitals more efficiently.

The system utilised a cloud-based medical record to keep track of all the data necessary to provide the most recent information on each patient. The doctor can treat the patient with care now that he or she can access the patient's medical records. The proposed method, which prioritises the provider-to-provider system, enables patients in rural and remote areas to receive support from healthcare practitioners. Telemedicine can be utilised to expedite the delivery of primary medical care [32]. Patient information is gathered using free, open-source software like the Android client.

Structured query language (SQL) was the underlying database management technology for the patient database. [33] address the benefits of telemedicine in medical care delivery. Since telemedicine technology makes it easier for physicians to treat patients remotely, pediatric care units stand to gain significantly from its implementation. Telemedicine was once restricted to hospitals in distant areas without access to a reliable healthcare system. As technology has progressed, however, telemedicine has replaced traditional medicine as the favoured option in most hospitals.

In the United States, remote medical treatment is widespread, and attempts are being undertaken to expand the network to densely populated areas [34]. One of the numerous benefits of the telemedicine system is the increased accessibility to medical facilities. Direct-to-consumer marketing [35] allows patients to schedule their medical visits conveniently. The availability of video calls increases a patient's ability to communicate with their physician. The primary impediment to the widespread adoption of telemedicine is concern about the care's quality and safety [36].

The function of telecardiology in telemedicine was analysed. With telecoronary care, the unit providing immediate treatment to the patient can quickly contact a remote cardiologist. Several technologies and Iot of Things-based apps must be developed to transport health-related information from faraway places to appropriate medical facilities. However, teleintensive care unit (tele-ICU) systems can lower rates of death and complications.

By enabling the continuous transmission of vital indicators from patients to central monitoring facilities, such as heart rate, respiration rate, and temperature, the tele-ICU system promotes telemedicine [37]. As a result, the medical professionals at the centralised monitoring facility

can support the nurses and other caretakers at the bedside round-the-clock. Sending an ECG to a physician for an additional 30 treatments is the most essential telemedicine uses.

Echocardiography is a crucial technology used by cardiologists to understand the function of the heart better, and electrocardiogram (ECG) data can be transmitted using a mobile device, like a smartphone or tablet, or a PC [35]. Cardiac data can be remotely transmitted to the appropriate healthcare facilities using echo telemedicine technology. The ability of the operator to control the ultrasonic imaging device is crucial to the effectiveness of the teleechocardiography technique.

In [38] opinion, telemedicine can potentially eliminate the disparity in healthcare access between urban and rural areas. The entire workflow of a telemedicine system, including the quickest way to connect a patient and doctor, must be explained to a practitioner [37]. The article makes several recommendations for how to implement telemedicine in India. The telemedicine platform should make it simple for doctors to communicate with their patients. The patient becoming a technology expert to operate cutting-edge technological machines as required [39] is one of three key factors affecting the telemedicine system's effectiveness. The other two are providing the patient with adequate Internet access for better communication and providing the patient with appropriate medical mentoring.

Data processing is essential to the operation of a telemedicine system. The information from video recordings of patient and physician teleconsultations must be processed appropriately [40]. Before telemedicine services are widely used, several requirements must be satisfied, claim Renner et al. The authors' telemedicine research, crucial in this process, defined the underlying mechanisms that deliver reliable, high-quality telehealth care. Three telemedicine initiatives that have been in place in Italy for a while were thoroughly examined throughout a six-year investigation.

Using information from a database maintained by the Health Ministry, an assessment of medical services in Italy was done between 2008 and 2010. In order to develop effective telemedicine services, it is helpful first to recognise the various scenarios that can occur within the field [41]. The conclusions concur that organisational and financial stability is essential for telemedicine services.

Having in-depth medical knowledge and providing exceptional patient care can raise organisational stability and professional acceptance. Modern technology allows staff nurses on demand, which supports organisational stability [42]. Hospital administrators and decision-makers have shown that financial stability is improved [43].

In order to establish normative data for newborns during their first 12 hours of life, the Children's Hospital was used in this study. Heart rate (HR), indirect blood pressure (NIBP), abdominal (Ta), and periphery (Tf) temperatures were among the parameters taken. The study assessed how well newborns born in TCHs, PHCs, homes, or earlier could adapt to the transition.

Infants born in tertiary hospitals, primary care clinics, and rural families and those born in urban, suburban, and rural settings did not adapt to their environments as quickly as anticipated.

A few of the numerous inferences that could be made are listed below: One is that infants born in tertiary hospitals are more adaptable than those born in primary care facilities or at home. Electronic monitoring is equivalent to a comprehensive clinical evaluation of infants to identify signs of inadequate transition.

III. METHODOLOGY

When the baby cries, the motor control unit moves the cradle. Both engines are under the operator. A nearby device records cradle activity.

Pediatric treatment uses automated oscillometric blood pressure monitoring, especially for infants and young children. Cuffing squeezed body parts helps treat them. Vessels pulse when cuff pressure falls below artery systolic pressure [44]. Pulsations send these oscillations to the cuff's transducer. Systolic pressure rises when a deflated cuff oscillates. The diastolic pressure is obtained when cuff oscillations stop falling, and the mean pressure is reached when they are at their lowest and maximum [45].

Fig. 1 shows the entire processing unit. The toy's primary purpose is to distract the infant from crying. After naps, babies cry. Stimulating toys reduces crying [43]. A baby's screams rotate the toy for five minutes. Adjust the toy's spin rate.

A blood pressure gauge connected to a newborn cuff, a patient connected to a SpO2 sensor, and two temperature probes were all connected to the 55 multiplex monitors before it was delivered. A cozy blanket and a dish were given to each infant upon arrival. The birth was formally announced after the umbilical cord was clamped.

After washing the infant's right hand, the SpO2 sensor was fitted. The apparatus was connected to the patient. The left hypochondrium (above the umbilicus) was surgically implanted with a central skin temperature probe. A circumferential skin temperature sensor was attached via micropore tape to the heel of the foot.

Figure 2 shows the project's ATmega32 microcontroller circuit diagram. System components: Noise sensors record ambient noise levels. Most characteristics are created using one of four frequency bands, typically 0.5 to 74 hertz (4 to 7 Hz, 13 Hz, and 30 Hz) (Hz).

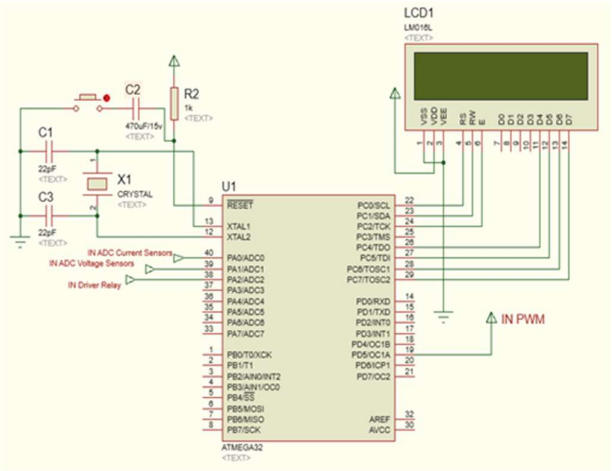

Fig. 2. ATmega32 Microcontroller Circuit Diagram

TABLE I. FEATURE EXTRACTION

Feature name	Description
spectral_power	Spectral power: absolute
spectral_relative_power	Spectral power: relative (normalised to total spectral power)
spectral_flatness	Spectral entropy: Wiener (measure of spectral flatness)
spectral_entropy	Spectral entropy: Shannon
spectral_diff	Difference between consecutive short-time spectral estimates
spectral_edge_frequency	Cut-off frequency (fc): 95% of spectral power contained between 0.5 and fc Hz
FD	Fractal dimension
amplitude_total_power	Time-domain signal: total power
amplitude_SD	Time-domain signal: standard deviation
amplitude_skew	Time-domain signal: skewness (absolute value)
amplitude_kurtosis	Time-domain signal: kurtosis
amplitude_env_mean	Envelope: mean value
amplitude_env_SD	Envelope: standard deviation (SD)
connectivity_BSI	brain symmetry index (see Van Putten 2007)
connectivity_corr	Correlation (Spearman) between envelopes of hemisphere-paired channels
connectivity_coh_mean	Coherence: mean value
connectivity_coh_max	Coherence: maximum value
connectivity_coh_freqmax	Coherence: frequency of maximum value
rEEG_mean	Range EEG: mean
rEEG_median	Range EEG: median
rEEG_lower_margin	Range EEG: lower margin (5th percentile)
rEEG_upper_margin	Range EEG: upper margin (95th percentile)
rEEG_width	Range EEG: upper margin-lower margin
rEEG_SD	Range EEG: standard deviation
rEEG_CV	Range EEG: coefficient of variation
rEEG_asymmetry	Range EEG: measure of skew about median
IBI_length_max	Burst annotation: maximum (95th percentile) interburst interval
IBI_length_median	Burst annotation: median interburst interval

IV. RESULTS

WSNs connect sources and targets via wireless channels. The source sends fixed-length data packets. Network RTT or RTD is the time it takes to send a data packet and receive a response. An analytical model will help us understand WSN end-to-end delay distribution. The device-to-server data transfer takes time. Current RTT formula:

$$\mathrm{RTT} = T_{\mathrm{MS}} + T_{\mathrm{SM}} + T_{\mathrm{PD}}: \qquad (1)$$

TMS is the time it takes the mobile device to send data packs to the server, TSM is the time it takes to get a response, and TPD is the processing delay. Sensor processing delays include data collecting and decoding, data transfer to the mobile device, and server diagnostics.

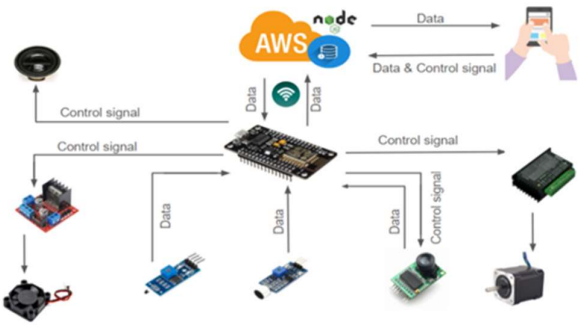

Fig. 3. Components of Signal Analysis

This system recommends 2048-bit packets. Assume the channel averages ten kbps. Despite the processing time being much less than the data transfer time, TD should represent transmission delay, N packets, and R transmission rate.

Responding to the source takes 204.8 milliseconds (DT2) is 204.08 ms. TPD values for random transmissions are 30–50 milliseconds.

$$30\text{ms} \leq T_{\text{PD}} \leq 50\text{ms}: \quad (2)$$

The average RTT for 100 data transfers can be calculated if the TPD value for the first 20 transfers is 34 milliseconds.

The formula is used to determine the duration of data transmission.

$$T_D = \frac{N\cdot}{R} \quad (3)$$

TPD is expected to be 40 milliseconds (ms) for transmissions between 20 and 40, 31 for 40–60, 43 for 60–80, and 39 for 80–100. Analytical results and experimental data are shown in Table 2.

TABLE II. AVERAGE RTT VALUES

Data transmissions (iterations)	Average RTT values (ms)	
	Experimental	Analytical
1-20	441.1	443.6
20-40	447.1	449.6
40-60	437.55	440.6
60-80	450.8	452.6
80-100	446.1	448.6

$$\text{RTT} = T_{\text{MS}} + T_{\text{SM}} + T_{\text{PD}} = 204{:}8 + 204{:}8 + 34 = 443{:}6\,\text{ms}: \quad (4)$$

Performance Evaluation Data transfer sends the patient's body temperature to their mobile device and the hospital server. Table 3 shows DDR values.

TABLE III. DATA DELIVERY RATIO CALCULATION

Time (s)	Data sent (bytes)	Data received (bytes)	Data delivery ratio (%)
1	118	116	98.3
5	493	486	98.5
10	802	789	98.4
15	1236	1220	98.7
20	1613	1575	97.6
25	1988	1960	98.5
30	2360	2320	98.3
35	2738	2701	98.6
40	3119	3050	97.7
45	3502	3425	97.8
50	3881	3806	98

Hence, the proposed architecture maintains DDR over 97.5%.

$$\mathrm{DDR} = \left(\frac{\mathrm{SDR}}{\mathrm{SDS}}\right)^{r} 100, \qquad (5)$$

TABLE IV. THROUGHPUT CALCULATION

Time (s)	Data received (bytes)	Throughput
10	789	78.9
20	1575	78.75
30	2320	77.33
40	3050	76.25
50	3806	76.12

$$T = \frac{D_R}{E_t}. \qquad (6)$$

SDS is sent mission, control, and automate (ICCUBEA), whereas SDR is a sensor that enters the data at the server in bytes (ICCUBEA). This thesis examined sensor-based wireless patient monitoring system issues. Android smartphones can remotely monitor without a computer as local databases. The hospital's primary server receives latitude and longitude data to track the patient's whereabouts.

A prototype with a temperature sensor tests the algorithm's performance, and a real-time system monitors patients. Infant care is challenging worldwide. They are essential because they will shape our culture. This technique emphasises neonatal care in modern times.

Red flashes suggest a moist mattress. Four infants are investigated. Infants who sleep in cradles without toys or auto swings are considered.

The two-wire serial communication protocol links block B to the MAX86150 ECG and the PPG sensor in block C. Block D and Block B are connected by the MAX30102 reflecting SpO2 sensor using the clock and data wires. Serial data and clock connect block E's MAX30205 temperature sensor to Block B.

Block F's HDMI connection to Block A lets the local system watch the output. Block A connects to Block G, where the operating system and data storage exist. The proposed system

couples block A of block H to an SDRAM. Block I uses a digital camera to send and receive patient video data from Block A. Block J is a USB-connected wireless security gadget.

V. CONCLUSION

The "Secure Automatic Patient Monitoring System" is a time-saving solution for parents who require a dependable and efficient patient monitoring system that collects body parameters continuously.

Communicative research on sensor-based wireless patient monitoring systems was conducted for this article. A temperature sensor is utilized at several points during the production of the BSN. This obstacle can be overcome by using an android smartphone instead of a PC because of the latter's inability to perform the duties of a local database. Additionally, it enables monitoring from a remote location. After the performance has been validated with a temperature sensor prototype, a real-time version of the system is utilized to monitor patients, which helps understand how the patient monitoring system performs strictly, which needs to be done. In any part of the world, it could be challenging to master the skills necessary to care for a newborn child effectively. We are committed to them because they will ultimately decide the course of events for our entire society. This strategy was conceived in response to modern concerns and to highlight the significance of baby care. This approach was chosen despite the notion that a baby is comfortable when held in the mother's lap. Because of its low cost and intuitive operation, this device is a good choice for busy parents with limited time to devote to their children's care. It is one of the many reasons why it is so tempting. Video playback capabilities are included in the vast majority of the most popular Android smartphones.

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