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WSNs BASED ON SUGAR CANE INDUSTRIAL MONITORING & CONTROL USING ENERGY EFFICIENT ALGORITHM

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ABSTRACT

Nowadays wireless sensor networks (WSNs) have attracted a great deal of study due to their wide range applications and low cost in the field of wireless networking. Advances in microelectromechanical systems, embedded microprocessors, wireless communications, and networking technologies have made WSN of large scale applicable to a wide range of applications, such as environmental monitoring, navigation and control of moving vehicles, machine condition monitoring and maintenance, disaster recovery and health care. This paper focuses on a low cost distributed data collection system using WSNs based on embedded Ethernet. Embedded Ethernet is nothing but a microcontroller which is able to communicate with the network. Enabling a microcontroller to communicate to a data communication network would allow greater flexibility and enhance their usage in several applications that require distributed data collection, monitoring or controlling such applications [1]. We stress emphasis on sugarcane industrial management using Ethernet. PIR sensor, load cell, color and temperature sensor are used to detect the industrial conditions such as presence of human using PIR sensor; load cell to find the weight of sugar cane; color sensor to find the color of baggage and temperature sensor to find Boiler temperature. We can fix some threshold values for sensors, if determined value exceeds then automatically motor can be stopped. The result would be a lower cost program with more frequent data collection, increased safety, and lower spare parts inventors.

KEYWORDS: ARM926EJ-S, Energy Efficient, Ethernet and Sensor Networks, Sugarcane Industry, Wireless Sensor Networks (WSNs)

INTRODUCTION

Wireless Sensor Networks (WSNs) have naturally emerged as enabling infrastructures for cyber-physical applications that closely interact with external stimulus. WSNs are mainly aimed at control and monitoring applications where relatively low data through put and large scale deployment are the main system features. Advances in microelectromechanical systems, embedded microprocessors, wireless communications, and networking technologies have made wireless sensor networks of large scale applicable to a wide range of applications, such as navigation and control of moving vehicles, environmental monitoring, machine condition monitoring and maintenance, disaster recovery, and healthcare[2][8]. WSNs are mainly aimed at monitoring and control applications where relatively low data through put and large scale deployment are the main system features. The sugarcane industry includes processes for exploration, extraction, refining, transporting, and marketing sugar and sugar products.

In existing system Distributed Data Collector (DDC) is a framework to ease and automate repetitive executions of console applications (probes) over a set of LAN networked Windows personal computers. The framework allows for the remote execution of probes, providing support for collecting the execution output of probes. Additionally, right after a probe execution, the output can be processed by user defined code that can act accordingly to user's needs. The framework can be useful to perform repetitive large-scale monitoring and administrative tasks over machines with transient availability, that is, machines that present no guarantees of being available at a given time. A major strength of DDC lies in the fact that it does not require installation of software in remote nodes, avoiding administrative burdens that remote daemons and alike normally provoke. The disadvantages in existing system are

- This method of DDC lacks in security.
- Although very versatile, the system does not have a strong security structure.
- No software should be installed at remote machines in order to avoid administrative and technical burdens.

This paper addresses the issues and challenges of using wireless sensor networks for monitoring and control of sugarcane industry operations. Distributed data collection is one of the most important applications of WSNs, in which, due to the limited resources for sensing, communication and computation, the network must rely on sensor management to balance the sugarcane industry accuracy and energy consumption.

We stress emphasis on sugarcane industrial management using Ethernet. PIR sensor, load cell, color and temperature sensor are used to detect the industrial conditions such as presence of human using PIR sensor; load cell to find the weight of sugar cane; color sensor to find the color of baggage (if the color is black then baggage will goes to garbage, else we can use the baggage to make white papers) and temperature sensor to find Boiler temperature. We can fix some threshold values for sensors, if determined value exceeds then automatically motor can be stopped.

The values of the sensors will be sent to LPC2921 Microcontroller. LPC2921 MC is also connected to ETHERNET and PC through LAN connection .We can connect different PCs through LAN connection and monitor the sensor values. Relay is connected with microcontroller to control the external devices such as motor, cooling fans.

RELATED WORK

Sugarcane processing is focused on the production of cane sugar (sucrose) from sugarcane .Other products of the processing include baggage, molasses, and filter cake. Baggage, the residual woody fiber of the cane, is used for several purposes: fuel for the boilers and lime kilns, production of numerous paper and paperboard products and reconstituted panel board, agricultural mulch, and as a raw material for production of chemicals. Baggage and baggage residue are primarily used as a fuel source for the boilers in the generation of process steam.

Thus, baggage is a renewable resource. Dried filter cake is used as an animal feed supplement, fertilizer, and source of sugarcane wax. Molasses is produced in two forms: inedible for humans (blackstrap) or as edible syrup. Blackstrap molasses is used primarily as an animal feed additive but also is used to produce ethanol, compressed yeast, citric acid, and rum. Edible molasses syrups are often blends with maple syrup, invert sugars, or corn syrup.

We stress emphasis on sugarcane industrial management using Ethernet and describe a low cost distributed data collection system based on embedded Ethernet WSNs. Embedded Ethernet is nothing but a microcontroller which is able to communicate with the network. Low cost microcontrollers have memory limitations, and therefore, have limited connectivity options. Enabling a microcontroller to communicate to a data communication network would allow greater flexibility and enhance their usage in several applications that require distributed data collection, monitoring or controlling such applications WSNs. PIR sensor, load cell, color and temperature sensor are used to detect the industrial conditions. The values of the sensors will be sent to LPC2917 microcontroller. LPC2917 MC is also connected to ETHERNET and PC through LAN connections .We can connect different PCs through LAN connection and monitor the sensor values. Relay is connected with microcontroller to control the external devices such as motor, cooling fans.

ENERGY EFFICIENT DATA COLLECTION

This section described about the distributed and energy efficient algorithm for data collection using WSNs [3]. The scheme is a distributed estimation algorithm where each node in the network senses the parameter and there is no hierarchical dependency among the nodes. Nodes in a neighborhood periodically broadcast their information based on a threshold value.

In this section the schematic flow diagram of the distributed and energy efficient algorithm for data collection is presented [4]. In this schematic diagram PIR sensor, load cell, color and temperature sensor are used to detect the industrial conditions such as presence of human using PIR sensor; load cell to find the weight of sugar cane; color sensor to find the color of baggage and temperature sensor to find Boiler temperature. All these four sensors, LAN through PC and ETHERNET are connected to LPC2917 Microcontroller. A relay circuit is also connected to LPC2917 MC to control the external devices like motor and cooling fan.

LPC2917 Microcontroller

In this paper the LPC2917 Microcontroller plays the major roll for controlling. This Microcontroller collects the data from the sensors. Whenever the sensor value exceeds threshold level, the MC starts controlling. For example if the temperature sensors value exceeds the threshold value, then automatically the microcontroller switch on the fan to reduce the boiler temperature. After reached the boiler temperature to the required level the microcontroller will switch off the fan. Likewise the microcontroller performs the all the controlling operations. Along with the sensors the microcontroller is also connected to ETHERNET and PC through LAN for transmitting the data to monitor the sensor values.

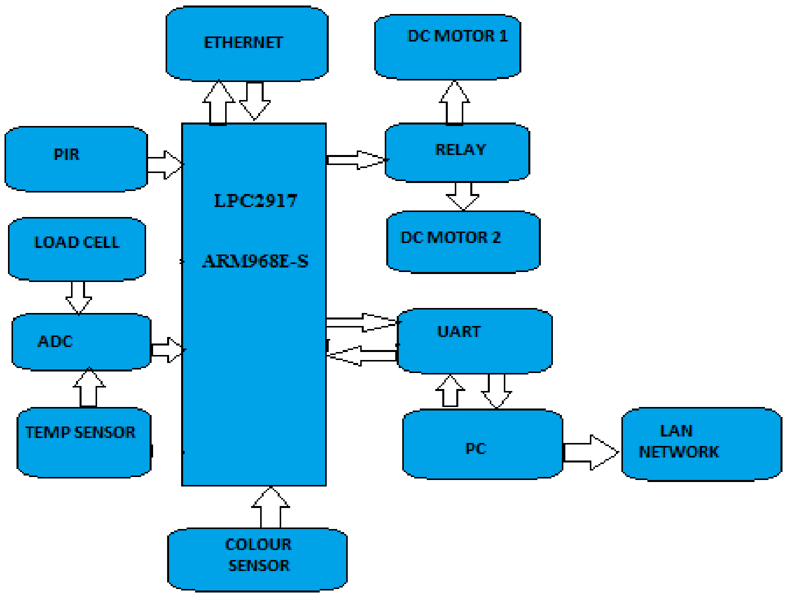

Figure 1: The Schematic Flow Diagram of the Proposed Energy Efficient Algorithm for Data Collection

The LPC2917 Consists of

- An ARM 968E-S processor with real-time emulation support.
- An AMBA multi-layer AHB (Advanced High-Performance Bus) for interfacing to the on-chip memory controllers.

- Two DTL buses for interfacing to the interrupt controller and the clock, power and reset control cluster (also called subsystem).
- Three VLSI peripheral buses (VPB) for connection to on-chip peripherals clustered in subsystems.

The LPC2917 configures the ARM968E-S processor in little- endean byte order. All peripherals run at their own clock frequency to minimize the total system power consumption. The AHB2VPB bridge used in subsystems contains a write ahead buffer one transaction deep.

The ARM968E-S is a general purpose RISC processor of 32-bits, which offers very low power consumption and high performance. The architecture of ARM is based on Reduced Instruction Set Computer (RISC) principles.

The instruction set and related decode mechanism are very simpler than those of micro programmed Complex Instructions Set Computer (CISC). This simplicity results in a impressive real-time interrupt response and high instruction throughput from a very small and cost effective core controller. Amongst the most compelling feature of the ARM 968E-S are:

- Separate Tightly Coupled Memory (TCM) interfaces and directly connected instructions.
- Write buffers for the Advanced High-Performance Bus (AHB) and TCM bus.
- Enhanced 16 x 32 multiplier capable of single-cycle MAC operations and
- 16-bit fixed- point DSP instructions to accelerate signal processing algorithms and applications.

Pipeline techniques are employed in this so that all parts of the processing and memory systems can operate continuously. The ARM968E-S is based on the ARM v5TE five-stage pipeline architecture. Typically, in three-stage pipeline architecture, while one instruction is being executed, the next instruction to it is being decoded and third instruction is being fetched from memory. In this five-stage pipeline architecture additional two stages are added for memory access and write-back cycles.

The ARM968E-S processor employs a unique architectural strategy known as THUMB, which makes it suitable for high-volume applications with memory restrictions or to applications where code density is an issue. The idea behind THUMB is supper-reduced instruction set. Essentially, the ARM968E-S processor has two instruction sets:

- Standard 32-bit ARMv5TE SET
- 16-bit THUMB set.

The THUMB set’s length instruction allows it to approach twice the density of standard code of ARM while retaining most of the ARM’S performance advantage over a16-bit controller using 16-bit registers. This is possible because THUMB code operates on the same 32-bit register set as ARM code. ARM code provides up to 65% of the ARM code size, and 160%of the performance of an equivalent ARM controller connected to a 16-bit memory system[5].

Ethrenet

We described a low cost distributed data collection systems based on embedded Ethernet. Embedded Ethernet is nothing but a microcontroller which is able to communicate with the network. Low cost microcontrollers have memory limitations and have limited connectivity options. Enabling a microcontroller to communicate to a data communication network would allow greater flexibility and enhance their usage in several applications that require distributed data collection, monitoring or controlling such applications. Enabling a microcontroller to communicate to a data communication network would allow greater flexibility and enhance their usage in several applications that require distributed data collection, monitoring or controlling such applications.

LAN

A Local Area Network (LAN) provides networking capability to a group of computers in close proximity to each other such as in a school building, an office building or a home. A LAN is useful for sharing resources like printers, files, games, and other applications. A LAN is also connected to other LANs, Internet or other WAN. LANs are built with relatively inexpensive hardware like Ethernet cables, network adapters, and hubs. Wireless LAN and other more advanced LAN hardware options also exist.

PIR Sensor

A Passive Infrared (PIR) sensor is an electronic device that measures infrared (IR) light radiating from objects in its field of view. The PIR Sensor is a piezoelectric device that detects motion by measuring changes in the infrared levels emitted from surrounding objects. The motion can be detected by checking for high frequency signal on a single I/O pin.

- Single bit output
- Small size makes it easy to conceal
- Compatible with all Parallax microcontrollers
- 3.3V & 5V operation with <100uA current draw

Piezoelectric devices, such as the PIR sensor, have elements made of a crystalline material that generates an electric charge when exposed to infrared radiation. The changes in the amount of infrared striking the element change the voltages generated, which are measured by an on-board amplifier. The device contains a special filter called a Fresnel lens, which focuses the infrared signals onto the element. As the ambient infrared signals change rapidly, the on-board amplifier trips the output to indicate motion.

Load Cell

A **Load Cell** is a transducer which is used to convert force into electrical signal. This conversion is done in two stages. Through a mechanical arrangement, the force being sensed deforms a strain gauge. The strain gauge measures the strain as an electrical signal, because the strain changes the effective electrical resistance of the wire. A load cell consists of four strain gauges in a Wheatstone bridge configuration.

The electrical signal output is in the order of mille volts and amplified by an instrumentation amplifier before it can be used. The output of the transducer is plugged into an algorithm to calculate the force applied to the transducer. Although strain gauge load cells are the most common, there are other types of load cells as well. As an example, a hydraulic load cell is immune to transient voltages (lightning) so might be a more effective device in outdoor environments.

Temperature Sensor

The measurement of temperature is one of the fundamental requirements for environmental control and industrial control. There are many different types of sensors are available, and the type of sensor that will be used in any particular application will depend on several factors[6].

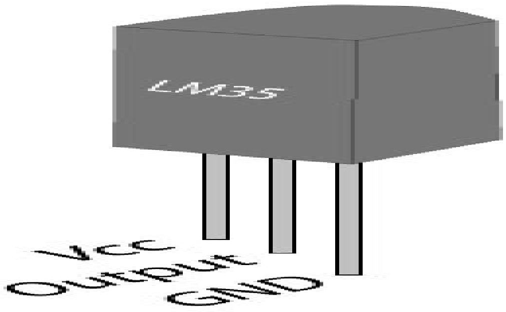

Figure 2: The Pin Diagram of the Temperature Sensor LM35

LM35 is a precision temperature sensor IC with its output proportional to the temperature (in °C). With LM35, temperature can be measured more accurately than with the thermister. It also possess low self heating and does not cause more than 0.1 °C temperature rise in still air[7]. The operating temperature range is from -55°C TO 150 °C. The output voltage varies by 10mV for every °C rise/fall in ambient temperature, and its scale factor is 0.01V/ °C.

Color Sensor

Color sensor is an interesting project for hobbyists. The colour sensor circuit can sense eight colors, i.e. blue, green and red (primary colors); magenta, yellow and cyan (secondary colors); black and white. This circuit is based on the basics of optics and digital electronics. The object whose colour is to be detected should be placed in front of this system. The light rays reflected from the object will fall on the three convex lenses which are fixed in front of the three LDRs. This Convex lenses are used to converge light rays and it helps to increase the sensitivity of LDRs. Blue, green and red glass plates (filters) are fixed in front of LDR1, LDR2 and LDR3 respectively. When reflected light rays from the object fall on the gadget, the coloured filter glass plates determine which of the LDRs would get triggered.

UART

A **universal asynchronous receiver/transmitter** is a type of "asynchronous receiver/transmitter", which is the key component of the serial communication subsystem of the computer hardware that translates data between parallel and serial forms. UARTs conjunctions with other communication standard such as EIA RS-232 are commonly used.

A UART is a individual or part of an integrated circuit used for serial communications. It takes byte of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Serial transmission of digital information through the single wire is much cost effective than parallel transmission through multiple wires. At the end of the link a UART converts the information between its sequential and parallel form. In each UART there is a shift register for conversion between serial and parallel forms.

UARTs are now commonly included in microcontrollers. A **DUART** (dual UART) combines two UARTs in to a single chip. Many modern ICs now come with a UART that can communicate synchronously, these devices are called **USARTs**.

MAX232

The **MAX232** is an integrated circuit that converts signals from an **RS-232** serial port to suitable signals for use in TTL compatible digital logic circuits. The MAX232 is a dual driver or receiver and typically consists of RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (± 7.5 V) from a +5Vsupply via on-chip charge pumps and external capacitors. This is useful for implementing RS-232 in devices that otherwise do not need any voltages outside 0V to + 5 V, as power supply design does not need to be made more complicated.

The receiver reduce RS232 inputs (± 25 V), to 5V TTL levels. These receivers have a typical hysteresis and typical threshold of 0.5 V and 1.3 V respectively. The MAX232A is backward compatible with original MAX232, but operate at higher baud rates and can use external capacitors of 0.1µF in place of the 1.0µF capacitors.

Relays

A relay is an electrically operated switch. Relay allows one circuit to switch another circuit which is completely separated from first. There is no electrical connection inside the relay between two circuits. The link between two circuits is magnetic and mechanical. The current flowing through the coil of the relay generates a magnetic field which can attract the lever and changes the position of the switch contacts.

The coil current can be ON/OFF so the relays have two switch positions and they are double throw single pole switches. Relays are generally SPDT or DPDT. But some relays can have many more sets of switch contacts, for example relays with four sets of changeover contacts are available. Most of the relays are designed for the PCB mounting.

DC Motor

A DC motor is an electric machine or motor that runs on direct current (DC). A permanent magnet DC motor is a rotating electric machine composed of two or more permanent magnet pole pieces. The rotor consists of windings which are connected to the commutators.

The stator magnet and the opposite polarities of the energized windings are attracted, and the rotor will rotate until it is aligned with the stator. Once the rotor reaches alignment, the brushes are move across the commutator contact and energize the next winding. Now the commutator is staggered from the rotor poles. If the connection of the DC motor is removed, the motor will change the directions.

The brushed DC motor advantages include low cost, simple control of speed of motor and high reliability. And these disadvantages are high maintenance and low life-span. The maintenance of DC motor involves regularly replacing the brushes and springs, cleaning or replacing the commutator.

NETWORKING MODEL OVERVIEW AND HIERARCHY

In this section, the architectural model of the sensor network is presented. In addition, the routing protocol that is used to collect and route sensor data from the sensing nodes to the data collection, dissemination, and base station nodes is discussed. In the hierarchical model used, three types of nodes are defined:

- **Basic Sensor Nodes (BSN)**: BSN are the most common nodes in the network. Their function is to perform the sensing function and communicate this information to the data dissemination nodes.
- **Data Relay Nodes (DRN)**: DRN nodes serve as control nodes for ON/OFF the motor and fan. The distance between these nodes is determined by the communication range of the networking MAC protocol used.
- **Data Dissemination Nodes (DDN)**: DDN nodes perform the functions of transmitting the collected data to the NCC and control data to the DRN.
- **Network Control Center (NCC)**: NCC controls the overall system functions. This implies that each of the DDN nodes would have this communication capability. These nodes are less frequent than the DRN nodes. Each DRN node reports to one DDN node.

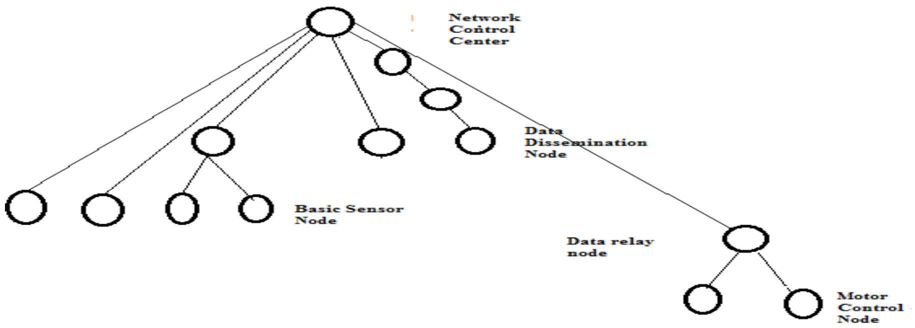

Figure 3: A Hierarchical Representation of the Sensor Network, Showing the Parent/Child Relationship of the Various Nodes

Figure 3 shows the hierarchical relationship between the various types of nodes in the sensor network. As shown in the figure 3, multiple BSN nodes transmit their data to one DDN node. In turn, several DDN nodes their data to a NCC node. Finally, all DSN nodes transmit their data to the network control centre (NCC).

RESULTS ANALYSIS

In this section, we described the simulations that have been performed on the proposed scheme. We presented here the results that are more relevant to our contribution, i.e. the performance of the sensor module. The results related to the energy consumption of sensor nodes and accuracy for different threshold values.

In the simulated environment, one of the applications is temperature monitoring. These nodes sense the boiler temperature continuously and send the temperature values to microcontroller. The temperature sensor senses the temperature ranging from 0-93 ^{o}c. Whenever the temperature exceeds threshold value, the microcontroller will automatically switch ON the cooling fan. The load cell gives the weight of the sugar cane. If the weight of the sugar cane is not sufficient then the motors will be turned off by the microcontroller. The PIR sensor identifies if the person is there or not. If the person is there it will shows the maximum value of 255, if not it shows some other value which is less than 255. The color sensor senses the color of juice of sugar cane. If the juice is white it shows 0, it shows 255 for black. If it shows value in between 0-255, that indicates that the color is in between white and black. All the sensor values and estimated results can be observed in the window shown in Figure 4.

All the sensor values are collected by the microcontroller, and microcontroller sends this sensor information to LAN network as well as to the internet through Ethernet. The information can be accessed by any person from any distance through internet, as shown in Figure 5.

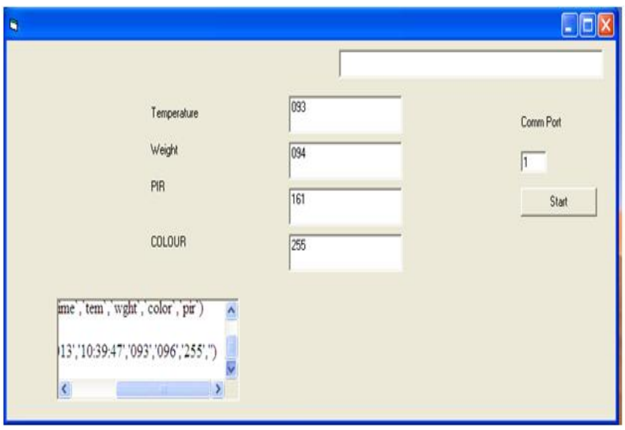

Figure 4: Estimated Results from the System

LogID	Temperature	Weight	Color	PIR	Logdate	LogTime
1	027	006	0	005	05/30/2013	11:27:28
2	023	007	008	005	05/30/2013	11:27:33
3	022	007	010	005	05/30/2013	11:27:38
4	024	007	005	0	05/30/2013	11:27:43
5	024	007	009	005	05/30/2013	11:27:48
6	022	007	000		05/30/2013	11:27:53
7	022	006	009	005	05/30/2013	11:27:58
8	022	010	012	005	05/30/2013	11:28:03
9	022		012	007	05/30/2013	11:28:08
10	022	006	000	255	05/30/2013	11:28:13
11	022	007		255	05/30/2013	11:28:18
12	034	007	000	006	05/30/2013	11:28:23
13	033	010	011	007	05/30/2013	11:28:28
14	033	007	255	255	05/30/2013	11:28:33
15	035	007	255	255	05/30/2013	11:28:38

Figure 5: The Time to Time Sensor Information from the Sugar Cane Industry in INTERNET through the ETHERNET Link

CONCLUSIONS

In this paper, we exploited the spatial correlation on the sensor data. It will reduce the communication energy during data collection from the sensor nodes and data distributed to the LAN and internet. We suppress the redundant data sent by data collection using a two-step strategy. First minimizing the number of transmission and second minimizing the data size by set of sensors at each neighborhood. We found the minimum number of bits required for data set of sensors using mutual differences and also found lower bound on the minimum number of transmissions for lossless data collection. In this paper, we found that minimum energy consumption during data collection from the set of sensors.

Based on our results, we introduced a practical algorithm for data collection which can reduce the overall energy consumption. And we can able to transfer the sensor information within the industry using LAN, and also to outside the industry using internet. So that we can monitor the conditions of sugar cane industry from long distance also. Finally, we presented the numerical simulations to verify the theoretical results. In future, more detailed analysis of other aspects of the model, including security and control, will be done. In addition to this performance optimization will be considered for various sensing and monitoring applications which generate different traffic conditions of network.

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