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Any Touch: Design and Implementation of a Touch Interface for Bluetooth Enabled Personal Devices

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Abstract

Human Computer Interactions has been a matter of great consideration for engineers, researchers, designers and industrial experts from decades. Every device, be it a smart phone, personal computer, ATM machines, etc. comes with a user interface for a layman to understand and to use the device. With the advancing technology, different modes of user interface are proposed. The most common of all is a touch interface. Most of the interactive devices now come with a touch interface. This paper presents an approach to provide a similar external touch interface for laptops and computers that further can modify for much smaller devices such as mobile phones.

Index Terms: Human Computer Interface, User Interface, Human-Machine Interaction, Touch Interface.

1. Introduction

The world has witnessed an exponential growth in the field of science and technology in recent decades. New inventions in the field of technology has brought a great change in the life of the masses throughout the world. Human Computer Interactions is one of the domains under exploration for past decade by many researchers, engineers, designers and industrial experts to make devices more interactive and easy to interface for amateurs and non-professionals. According to an article published by IEEE Computer Society, Human-Computer Interactions is a multidisciplinary research area focused on interaction modalities between humans and computer system.

In early days, computer designers focused on developing easy to understand human-machine interfaces, but

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later, the term, User Experience or UX was coined which also described the experience of the user using the system. For an easy to understand user interface and for improving user experience, multiple proposed techniques are found in both literature and practice. Between all these proposed techniques, a revolution came with the introduction of touch interfaces worldwide.

The touch interface brought a complete new thought for the user interface designers as well as engineers to make interactions more fun, adaptable and interesting for the users. Now, almost all of the devices come with a touch panel with an interactive interface. The question is what about the older devices with no such easy to understand and adaptable interaction feature? The paper presents an answer to this question by proposing an approach to design an external touch interface for any Bluetooth or USB enabled devices such as personal computers, laptops, etc.

The paper has five sections. The first section of the paper discuss about the present touch interfaces with introduction to their working principle, followed by the next section displaying the proposed system in words. The next section showcase the two designs prepared and tested for windows based computer setup. Finally, the paper ends with the observed results, concluding with response analysis of implemented system and how the proposed touch interface is better than others.

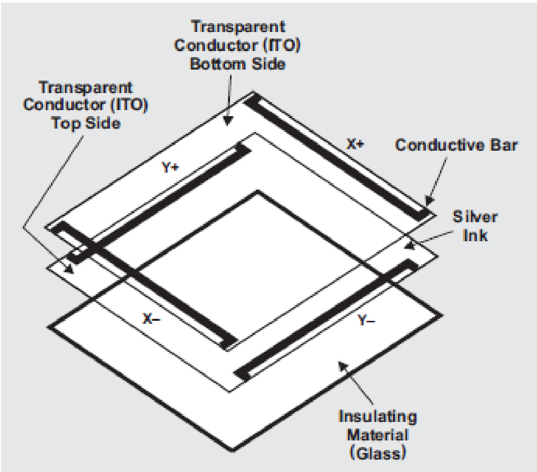


Fig.1. Layered Structure of Resistive Touch Interface

2. Touch Interfaces

Touch Interfaces are one of the most commonly available user interface medium in almost all sorts of devices. Touch Interfaces are effective in many information appliances, in personal digital assistants and many generic pointing devices. The most commonly used touch interfaces are either resistive or capacitive in nature. This section explains the operation of these two touch interfaces in brief.

2.1. Resistive Touch Interface

Resistive touch screens are widely used in applications such as smartphones (older versions), ATM and many other appliances. Resistive touch screens are comparatively cheaper and is easily available. It uses a four wire architecture (as shown in figure 2) to detect the location of touch in a two dimensional plane in form of two co-ordinates.

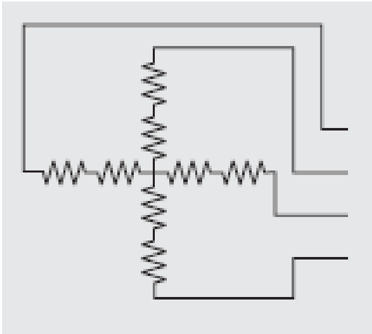


Fig.2. Four Wire Architecture

When a point is touched on a four-wire touch screen, the press on the screen makes the Transparent Conductor layers interact with each other (referring to figure 1). Electrodes on X-axes of the touch panel receives the voltage applied on the Y-axes, hence defining the X-coordinate of the touch. This contact made by the interaction of two layers create a voltage divider, hence deducing the Y-coordinate of the touch. The same process repeats by interchanging both the axes for more accurate results. A touch panel controller in case of a resistive touch is simply an analog to digital converter (ADC) that has built in switches to control both driving as well as input-detection electrodes.

2.2. Capacitive Touch Screen

Capacitive Touch sensing is one of the most popular technologies under practice among touch panels. It is highly durable, has an excellent optical performance, and can support unlimited multi-touch. They are generally made up of pure glass, making them immune of most of the chemicals and can be operated in extreme temperatures are well.

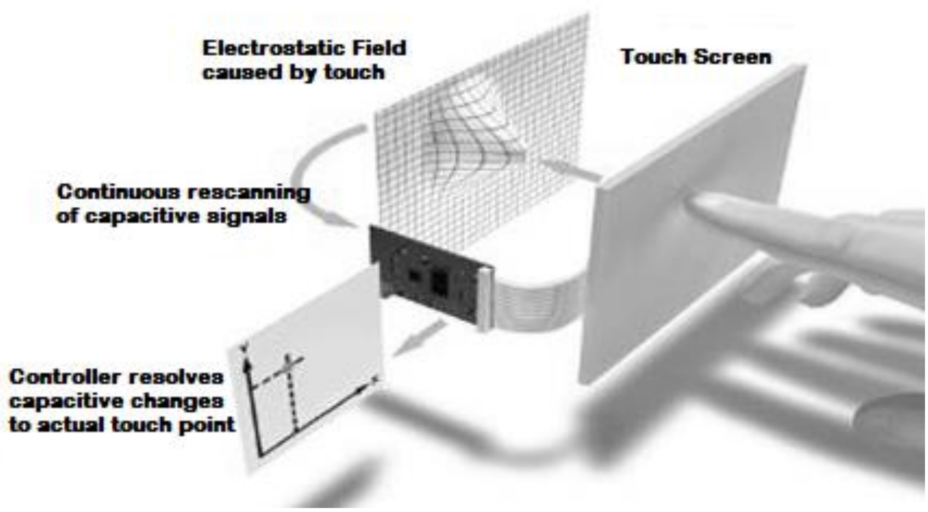


Fig.3. Capacitive Sensing Technique: The Conductor Plate and Finger Combined Acts as Two Plates of a Capacitor. As the Finger (Human Skin) Comes Close to the Screen, the Controller to Identify the Point of Touch uses Generated Distortion in Capacitance

Capacitive sensing is a very old technology. It makes use of the property, *human body acts as conductor for electricity*. In a capacitive touch panel, a coat of inductor (such as glass) is placed on a conductor (such as Indium Tin Oxide). Now, the conducting layer acts as one plate of a capacitor. When finger touches on the panel, an Electrostatic field generates, and a capacitance occurs at this point. At this point, a timer circuit and an RC network measures the location of touch on the panel.

3. Proposed External Touch Interface

The proposed device acts as a transmitter to the computer system or any device, which needs a user interaction. This proposed touch interface uses Bluetooth technology to interact with the computer setup. Software such as MathWorks' Matrix Laboratory (or MATLAB) processes the received data. Microcontroller such as AVR's Atmega168P acts as the central control unit for the device that detects the point of touch and controls the communication between the touch panel and the personal computer.

The system make use of micro-laser heads along with a photodiode or voltage divider circuit using a simple semiconductor resistor and light dependent resistor (LDR). The lasers are on the two adjacent sides of the screen. The LDR network or photodiodes are exactly opposite to the laser heads, hence making up the other two sides of the screen. A pair of laser head and photodiode (or LDR network) ensures a continuous beam of laser either horizontally or vertically on the screen. Whenever a user places his/her finger in this proposed touch interface, a laser from each axis will get disturbed and photodiodes (or LDR network) placed opposite to these laser heads detects the same. Hence, the system deduces the point of touch on the interface.

Figure 4 presents the structure of this proposed touch interface that can act as a keyboard. Figure 5 presents the working of such system. For practical purposes, an infrared (IR) module in two axis replaces the laser-photodiode pair.

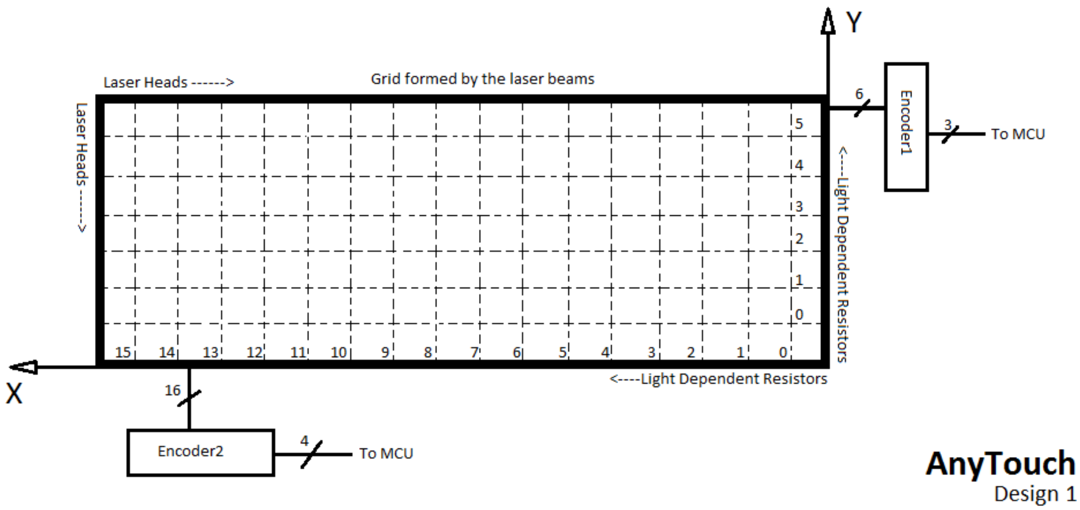


Fig.4. Structure of the Proposed Touch Interface in Form of a Keyboard

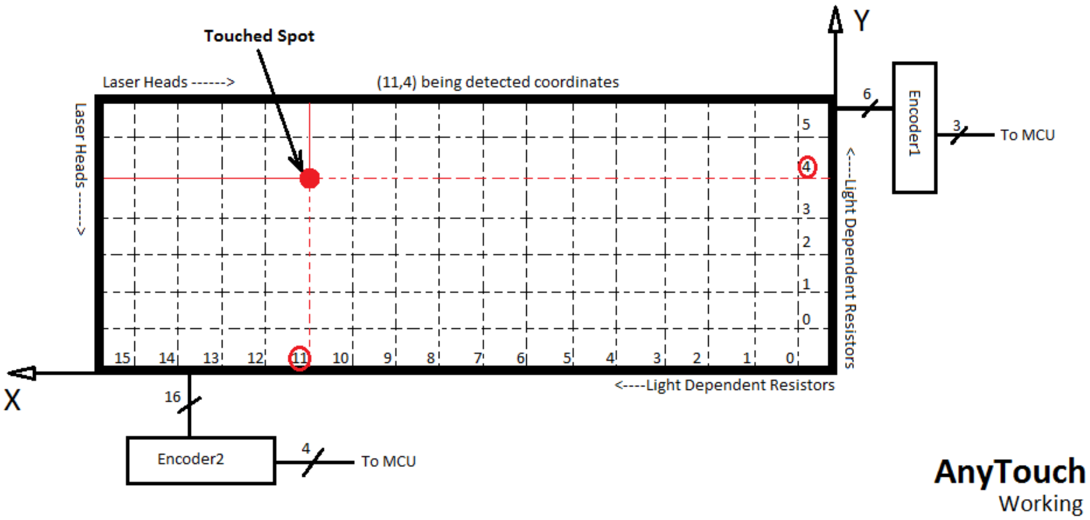


Fig.5. Working of the Proposed Touch Interface in form of a Touch-keyboard Structure

The above presented structure and working is for a keyboard. The test case for this theoretical example is a touch-based keyboard. This has about 20 LDR networks (or photodiodes) detecting the disturbances in the continuous laser beams on screen. Assume, we try to press digit ‘4’ on the keyboard (fifth key in the second row of keyboard). The fourth laser in the vertical axis and the eleventh laser in the horizontal axis discontinues, hence generating a logical ‘0’ at their respective photodiodes or LDR network. Rest of the photodiodes provides a logical ‘1’ to represent continuous reception of the laser beam. This, in turn changes the input fed to the two encoders, and microcontroller receives a different output from encoders. The microcontroller processes the data to define the point of touch and provides the output to the attached device accordingly.

4. Practical Implementation

The proposed design uses a laser-photodiode (or LDR Network) pair. The practically implemented test design uses simple infrared (IR) sensors. The practical demonstration presents a 3X4 Keypad model similar to the old mobile phones.

The flow chart used for the implementation is shown in figure 6. The implemented design is tested using a graphical user interface designed in MathWorks’ MATLAB. The device initially connects to the computer using Bluetooth. The device uses an HC-05 Bluetooth module for connectivity. Once the network between device and computer establishes, the complete sensor network initiates. Whenever a touch is introduced in the design, the infrared sensor in both horizontal and vertical direction detects the touch and sends the data to encoder programmed under microcontroller. The microcontroller then processes the data and transmits the same to MATLAB via Bluetooth network. Once the MATLAB receives the data, it starts displaying whatever is being types.

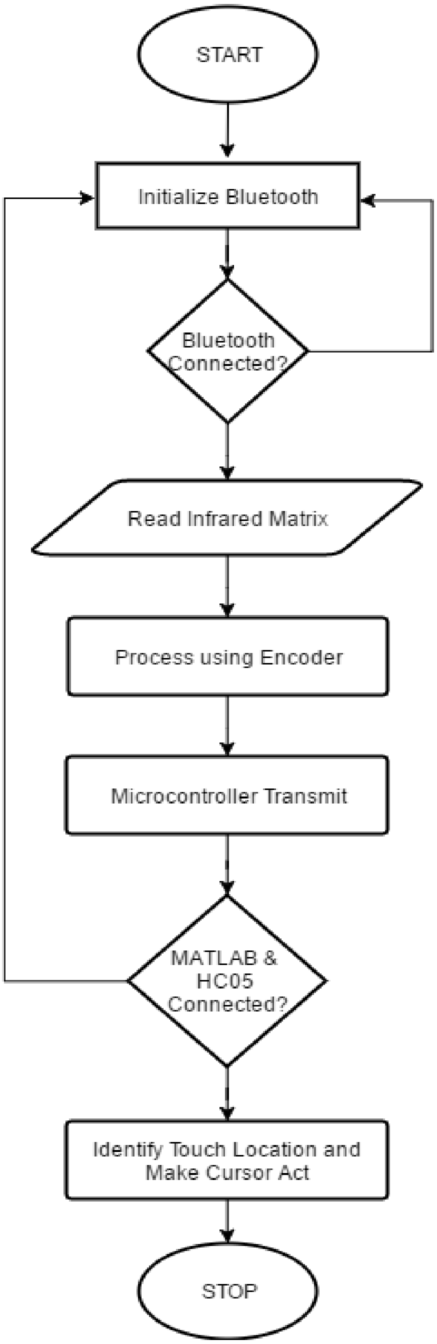


Fig.6. Flow Chart for Implemented System

The initial design of this practically implemented design is shown in figure 8. It has three infrared sensors in the horizontal direction, and four infrared sensors in the vertical direction. This sensor network is controlled using Atmega168P microcontroller placed in the circuit.

Fig.7. Block Diagram Representing Implemented Design

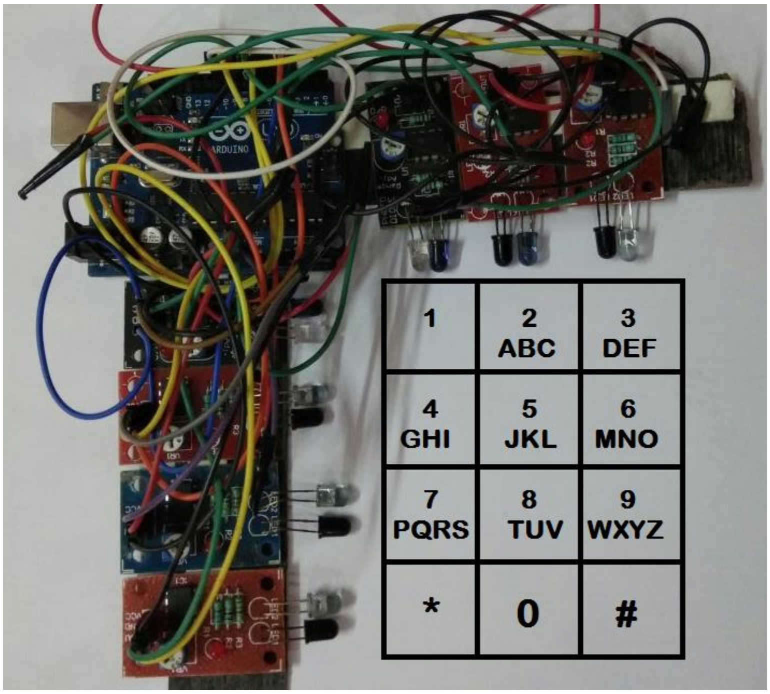


Fig.8. Practical Design using Infrared Sensor

At the computer end, the data received through Bluetooth interface is fed to MATLAB. A GUI is designed in MATLAB to record the live feed while using the design and the typed content is being written on the right hand side of the GUI. This graphical user interface is established as a test bench to test this first layout. After this, another design with 3X4 Infrared sensor network is designed which acts similar to a laptop's mouse trackpad. The 3X3 upper matrix is used to provide direction of motion to the mouse. The bottom left and bottom right are used as left and right clicks respectively.

5. Observations

The paper presents two of the implemented devices using infrared sensor. The design for the same can be seen in figure 8. This device acts as a keypad of old mobile phones. To analyze the working of this device, a test bench was established using MathWorks' MATLAB. Using GUI feature of MATLAB, a GUI was created to present the live feed of the touch being done in the hardware. This live feed is taken via a smartphone's camera attached through USB to the computer. And the typed content is presented on the right hand side of the GUI. The GUI layout can be seen in figure 9 and 10 presenting the user typing "HELLO WORLD". The GUI also have an option of saving the written content in form of a .txt file.

As seen in figure 9, as the user quickly taps on the first button of second row (number 4 with characters G, H and I), software receives it as the user pressed 'H' and shows the same on the right side of GUI.

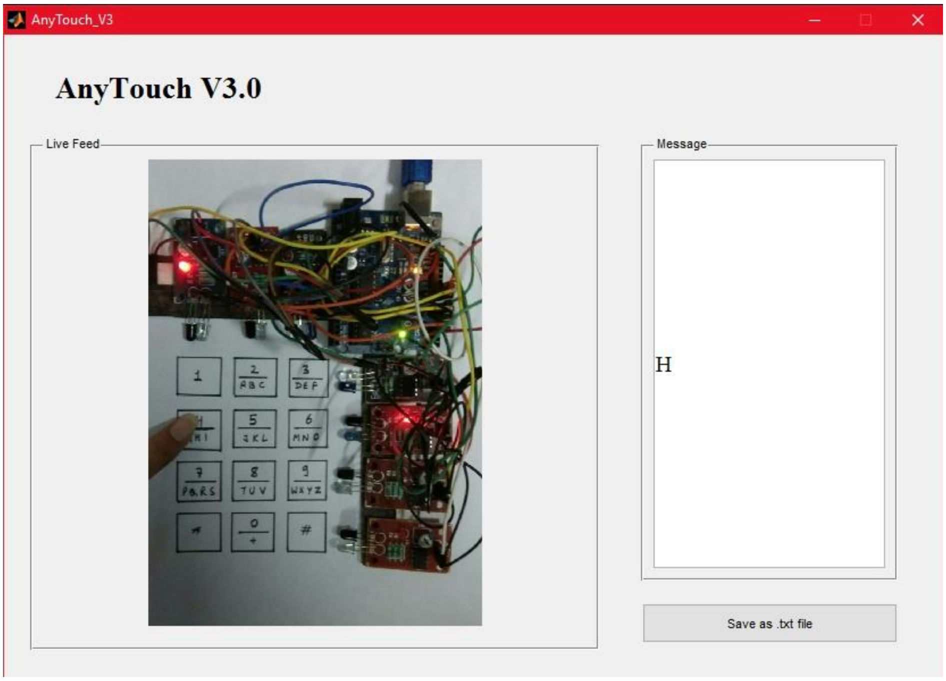


Fig.9. Live Feed is in form of Pictures at a gap of Approximately 500 Milliseconds. Whatever Being Typed by Clicking the Imaginary Button is Being Shown in the Messages Column of the GUI at the Right Side.

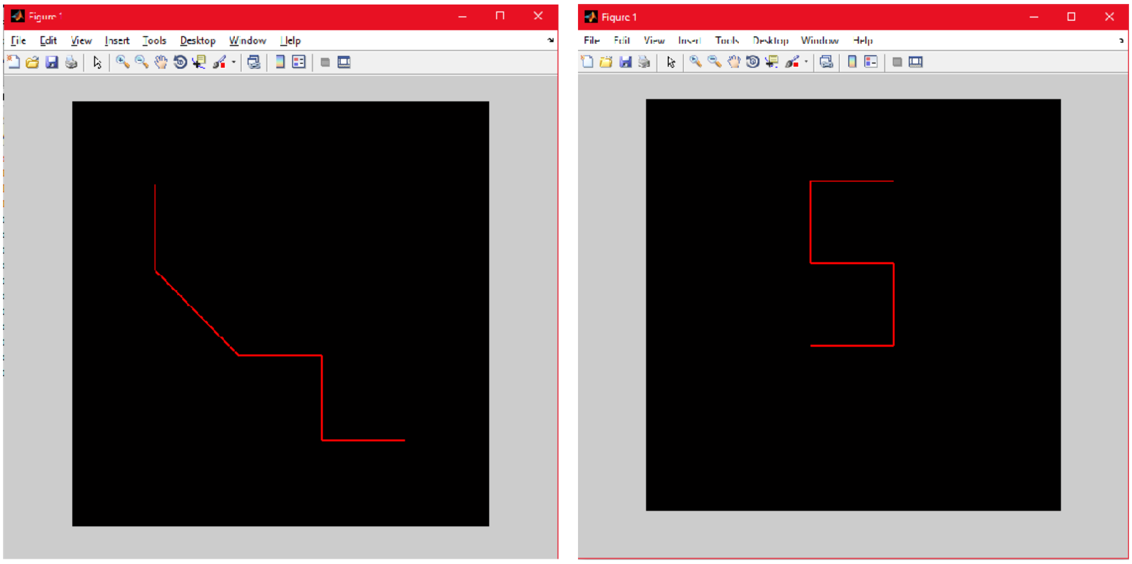
Fig.10. Typing "HELLO WORLD" using the Proposed Device.

After the successful test of the device, it can be concluded that the device is working fine. On further observations, it is seen that one can use any type of material such as a stick, a magnet, a translucent sheet, etc. and the device can easily detect it. This simply overcomes the disadvantage of the capacitive touch that only human skin will be operational. Also, one need not make strong press. A gentle touch in the air also works very smoothly, hence overcoming the disadvantage of a resistive touch, that a strong press is required so that the two layers can interact with each other.

The same device is upgraded in form of a mouse trackpad for the computer. The upper nine touch points act to direct the movement of mouse on the screen, and bottom left and right button acts as the left and right click of the mouse simultaneously.

To test this device, another test bench was established, that drew red lines from where-ever the cursor moves over a black surface. After a few iterations, it is observed that taking diagonal turns in the mouse is very difficult and curvy turns aren't possible for this system. Also due to high processing, the device is comparatively slow and there is a lag of approximately 300 milliseconds in the response of the mouse. To improve the sensitivity of cursor movement using this device, one has to increase the size of the sensor matrix. Larger the size of the matrix, more is the sensitivity of the device. To reduce the lag, simpler java scripts can be used instead of having very heavy processing softwares.

The output results for the cursor trackpad can be seen in figure 11. Figure 11(a) presents a simple '5' like shape traced using cursor trackpad, and figure 11(b) presents a random movement of the cursor using the trackpad.



(a) Random Cursor Movement using Trackpad (b) Shape of number '5' using Trackpad

Fig.11. (a) Random Cursor Movement using Trackpad, (b) Shape of number '5' using Trackpad

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