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## A Novel Approach to Designing Intelligent Vending Machines

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### ABSTRACT

*Rapid consumerism and techno-savvy trends recently have led to a sudden rise in interest by the vending machine industry to adopt latest technologies in order to increase their profit margins. With over 20 million vending machines installed worldwide, several technologies can be exploited to increase both - profitability as well as ease of customer-machine interaction. This paper explores the current preferences, future demands and trends that will transform the industry. To incorporate changing market dynamics, up-sell opportunity and increasing government regulations, vending machine designs have seen a paradigm shift towards computing technology. A range of technologies like LCD/touch-screen displays, image sensing, cashless payment and telemetry needs to be integrated. This paper covers various factors, including a design of an intelligent vending machine market forecast, key drivers, restraints and geography-focused insights. The paper proposes modifications in existing designs and discusses the role of latest technologies in this industry transformation.*

**KEYWORDS** – *Telemetry, Image Sensing, Intelligent Machines, ERP, remote management.*

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## 1. INTRODUCTION

The vending machine industry is undergoing a massive change, using intelligent system technologies to implement innovations as eclectic as HD touch-enabled screens and remote management device software to go far beyond from just simply dispensing food and drink. There is a strong urge for vending innovation from consumers and the machine owners, with many surveys indicating that they would use machines that would offer services and products both. Mobile phone charging, free Wi-Fi, and printing from USB drives were the most popular services. Product and machine owners would also be able to send various coupons to customers' personal cell-phones to encourage them to return to the machine or to direct them to purchase more products in the local store. RFID (Radio Frequency Identification) integration in WSN (Wireless sensor network) has been discussed by Ben et.al (2010). Ameer H. Morad's paper on GPS Talking for Blind People (2010) also encompasses and reaffirms the utility of such vending machines, especially for the differently abled people. M.Bhuvaneshwari et.al (2013) suggested the concept of automatic ticket vending machine by using RFID and Zigbee technique. This machine enables the passenger to predetermine the transport details. Sheng et. al. (2008) put forward their work on Enabling Next-Generation RFID Applications from challenges to solutions. Bo Yan and Danyu Lee (2009) highlighted design of sight spot ticket management system based on RFID. Goebel et. al. (2009) gave their perspectives on RFID in the Supply Chain with the intention of obtaining a positive return on investments. Venugopal Prasanth et. al. (2009) offered ticketing solutions for Indian Railways Using RFID Technology at International Conference on Advances in Computing, Control, and Telecommunication Technologies. By full utilization of the new technologies, each vending machine now becomes an intelligent system which offers a richer, and a more engaging customer experience, whether it's for selling soft drinks or for services.

According to research analysis, United States of America is the leading country when it comes to world Intelligent Vending Machine market because of the availability of secure and customer-friendly cashless payment options across the retail stores of the country. However, there is intense competition among vendors operating in this market which is posing a huge obstacle to the growth and development of this market. The yearly report of Japan Vending Machine Manufacturing Association (JVMA) showed that there were more than 6 million vending machines which served 130 million people of Japan. Japan has highest number of

vending machine in the world. Most of the vending machines sold beverages (48%), cigarettes (11%) and foods (2%). For the beverage, most vending machines sell soft drinks (84%), while the others sell milk (7.0%), coffee and chocolate drink (6%), and alcoholic beverages (3%). Yi-Chih Hsieh et. al. (2014) gave the above discussed results.

## 2. DISCUSSIONS: The Machine Design

### 2.1) PRIORITIES CONCERNING INTELLIGENT MACHINE ENHANCEMENTS

- 2.1.1) **LCD:** Touch-screen and user interactive displays, typically ranging between 8 and 42 inches.
- 2.1.2) **Cashless Systems:** Payment by applications installed on mobile phones and credit/debit cards.
- 2.1.3) **Telemetry Systems:** Fixed/wireless connections for communicating machine's health (i.e., sensors, inventory levels, etc).
- 2.1.4) **Voice Recognition:** Another user interactive way for customers to interact with the machine.
- 2.1.5) **Digital Signage:** To increase profitability-high definition content medium: product information, graphical and video advertisements. Rich interactive content.
- 2.1.6) **ERP:** Machines communicating with corporate systems like finance, product planning, dispatch of products that are facing shortage in the machine, and maintenance. For example: in an experiment conducted, results of the product removal in a vending machine were that many consumers started purchasing another product in the vending machine hence increasing the sales. This has been discussed in detail in the NBER working paper series in the paper "Efficiency and Foreclosure Effects of all-units Discounts: Empirical Evidence" by Christopher T. Conlon and Julie Holland Mortimer published by National Bureau of Economic Research, Cambridge (2013)

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**2.1.7) Power Saving:** Machine would go in hibernation mode if it doesn't sense any users in its vicinity leading to better power efficiency.

**2.1.8) Image Analysis/Gesture Recognition:** A simple example of this would be a person who yawns in front of the machine, is offered to have a coffee

**2.1.9) Automatic Ticketing for Transport Systems:** Automatic ticketing can also be introduced by using RFID and the Zigbee technique. The person can discover the destination place by pressing the options available on the machine with the aid of zigbee. If a location is selected, then the availability of the buses with the time is displayed. If people confirm to travel in a certain bus, then by using a smart card, a person can acquire the tickets by using RFID technique and then by showing the generated ticket while in front of bus, the door automatically opens and then after a few seconds it gets closed.

## **2.2) MARKET MOTIVATORS:**

**2.2.1) Opportunities enabled by cell phones:** Accepting payments and transfer of coupons with the swipe of a phone using near-field communication technology.

**2.2.2) Government mandates:** Display of product nutrition information and product warnings (i.e. smoking and tobacco). Recent Federal, state and local policies which targetted youth smoking emphasized on reducing youth accessibility to tobacco use via minimum legal purchasing age, restricted the sales through vending machines, banned self-service cigarette displays etc. Synar Amendment to the 1992 Federal Alcohol, Drug Abuse, and Mental Health Administration Reorganization Act, the FDA's 1996 final rule on "Regulations Restricting the Sale and Distribution of Cigarettes and Smokeless Tobacco to protect children and adolescents". This has been detailed by Frank and Rosalie (1998) at 3rd Biennial Pacific Rim Allied Economic Organizations Conference, Bangkok.

**2.2.3) Increased user interaction-** Interaction with both the customer and his smart phone, adding intelligence to detect and then respond to individual viewers, and providing a dynamically visual experience with high definition displays running on rich graphics and interactive promotions.

**2.2.4) Remote management** - Enabling machines to contact vending machine operators by sending and receiving real time notifications through cloud, thus decreasing the maintenance cost, increasing the machine availability and also automating facility of restocking. More importantly, the connected machines can also communicate when they're running low on products and can facilitate dynamic routing optimization along with other logistic efficiencies.

**2.2.5) Software flexibility** - Adopting general-purpose processors that are capable of easily supporting new technologies and features in the software as opposed to hardware-focused and fixed-function platforms.

**2.2.6) Pricing power** - Commanding a higher price for those products (e.g., coffee) that are purchased more by using a vending machine's high end technology display and also the interactivity to position them as higher quality than the others sold in the machines.

### **2.3) MARKET ROADBLOCKS:**

**2.3.1) Ethical/Moral Constraints:** Growing regulations that prohibit sales of junk food in schools and tobacco use in public.

**2.3.2) Return on investment concerns:** Troubled Economy, the market slowdown and use of high end technology costs also deter vending operators from upgrading their already existing machines.

**2.3.3) Theft and damage Issues:** Security issues in certain locations limit high end vending machine adoption.

**2.3.4) Costs of Rental space are excessively high in certain parts of India:** As rents rose 35% over the past years, operators re-localized or took back their machines.

**2.3.5) Low profit and operational margins:** Vending operators operate their business on very narrow profit margins and need to justify the purchase of new high end technology with an excessive increase in revenue.

### **2.4) INDUSTRIAL CHALLENGES:**

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**2.4.1) Management and regulation of Energy:** Recent emerging mandates require energy consumption to be low and improvement of monitoring.

**2.4.2) Integration of technology:** Vending operators who incorporate new technologies must also integrate latest protocols and standards.

## **2.5) HARDWARE SPECIFICATIONS:**

### **2.5.1) Altera Cyclone II FPGA**

- LCD Touch Screen functionality
- Vending State Machine
- Motor Driving

### **2.5.2) NIOS II soft-core processor**

- Host Communication
- Payment
- LCD Graphics Processing
- Sensors

### **2.5.3) Utilize currently existing bill/coin acceptors**

**Multi-Drop Bus (MDB):** It is a standard device for coin or bill accepting communication. Proprietary Ampere-controlled signal. It is not difficult to convert Multi-drop bus to any standardized protocol.

### **2.5.4) Role of MDB2PC circuit**

The MDB2PC is imperative for an interface with the industrial standard MDB Vending machine protocol into a standard PC. The MDB utilizes 11 Bits and 9 bit byte. The polling requirements for the various MDB devices are excessive (20-200 ms). A non-dedicated PC can not meet the polling requirements. This aids the PC to perform normal operations and counter interrupt driven communication events in the

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UART buffer. All data from an MDB device is made available to the PC. And conversely all commands can be sent to the MDB device from the PC.

#### 2.5.5) Utilizing existing motors

- **Modifying the hardware to drive the motors**
  - **Motors are intermingled into a matrix configuration:** Motor high/low signals are multiplexed to the rows/columns to select a solitary motor.
- **Motor Driving:**
  - 24V@500mA (this includes the in-rush current)
  - Motors running one at a time.
  - Operating at infrequent intervals, therefore, power dissipation does not cause a problem.

#### 2.5.6) Host Interface

- **Bluetooth, Zigbee and/or WiFi:** ZIGBEE is used primarily to transmit data over long distances by passing the data via intermediate devices that provides a much secure networking process. The automatic ticket vending machine comprises of displays which shows the availability of the buses for all the destinations. A person can find out the destination by just pressing those buttons which are available on the machine with the aid of zigbee technology.
- **Ethernet and RS232.**

### 3. FIGURES AND TABLES

#### 3.1) GEOGRAPHICAL TRENDS

	LCD	Cashless Systems	Telemetry Systems	Voice Recognition	Digital Signage	ERP
<b>North America</b>	★ ★ ★ ★ ★	★ ★ ★ ★ ★	★ ★ ★ ★ ★	★ ★	★ ★	★ ★
<b>Europe, Middle East, Africa</b>	★ ★ ★ ★ ★	★ ★ ★ ★ ★	★ ★ ★ ★	★ ★	★ ★	★
<b>Asia- Pacific</b>	★ ★ ★ ★ ★	★ ★	★ ★ ★ ★ ★	★	★ ★	★
<b>Latin America</b>	★ ★	★ ★	★ ★ ★ ★ ★	★	★ ★	★ ★

Figure 1: Geographical Star ratings for various sub-sets of intelligent vending machines.

**Key:**

- 5 stars : Highest Priority and acceptance
- 4 stars : High Priority and acceptance
- 3 stars : Average Priority and acceptance
- 2 stars: Low Priority and acceptance
- 1 star: Extremely Low Priority and acceptance

**3.1.1)** The diagram depicts the geographical estimates and the willingness of vending machine operators willing to adopt the varied technologies and is depicted with stars. The study gives us a tentative conclusion that North America would be the most willing to accept the new innovations, and have high feasibility, whereas, the other nations would thrive on this once there is a economic boom.

**3.2) HARDWARE LAYOUT USED**

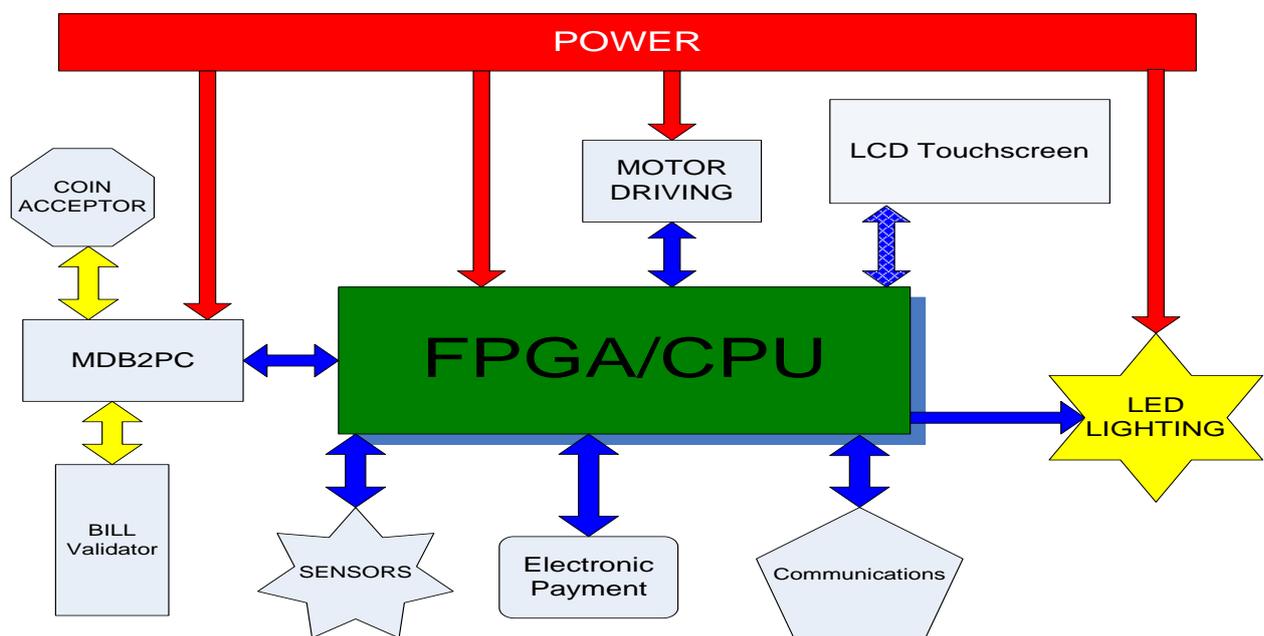


Figure 2: Hardware layout used.

**3.2.1) ARCHITECTURE**

- Motors, MDB2PC, CPU, and LED lighting are directly connected to the power outlet.

- Bill validator, coin acceptor, sensors, electronic payments and the LCD touchscreen are connected via the MDB2PC and the CPU respectively with the power outlet.

### 3.3) RS232 CIRCUIT DIAGRAM

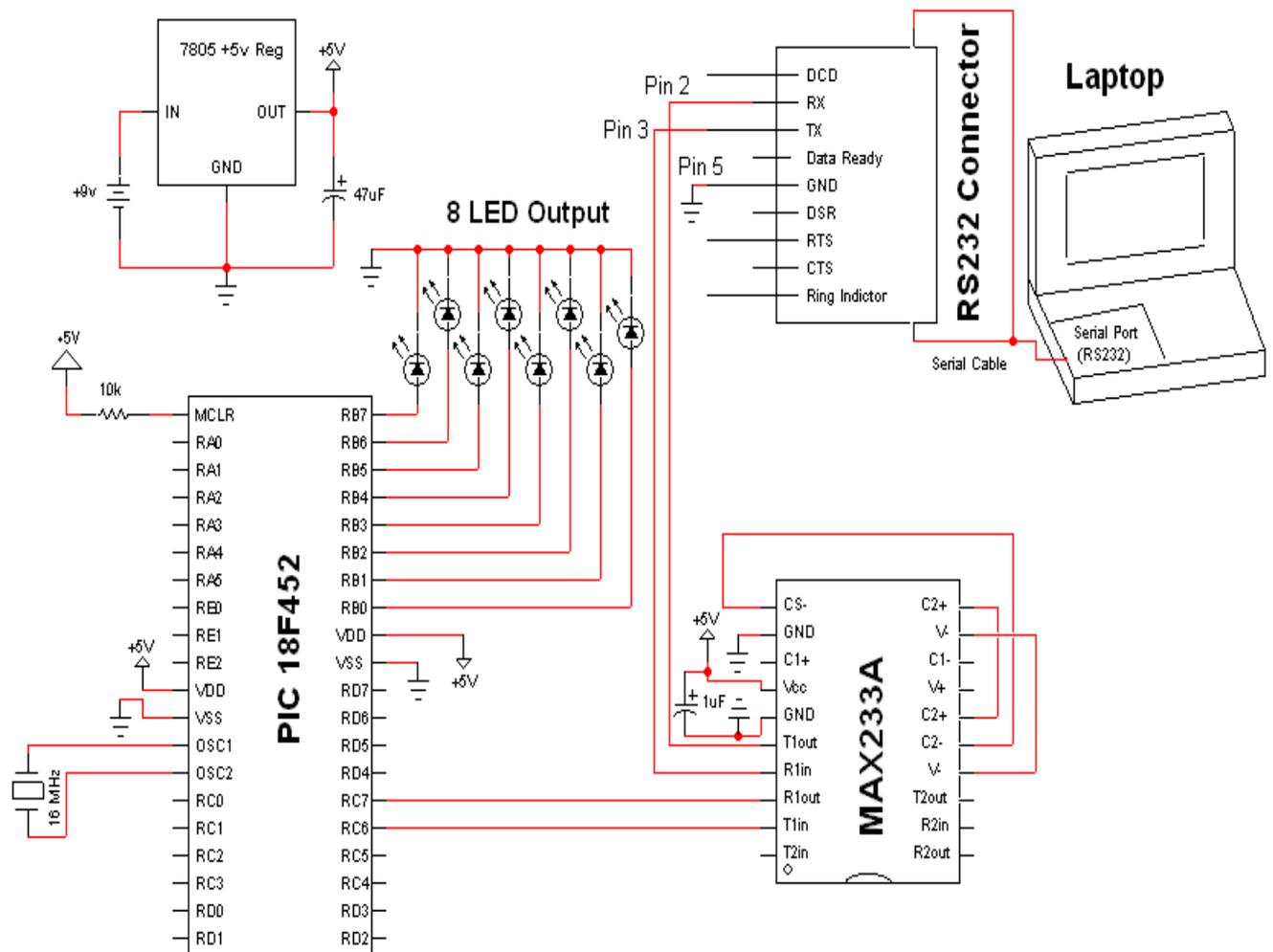


Figure 3: RS232 Circuit Diagram

#### 3.3.1) MDB2PC BOARD

- Hardware/Software Interface.
- For MDB to RS232 Conversion
- Allows controller board to communicate with coin/bill acceptor and process payments/payouts

#### **4. CONCLUSION**

The Vending Machine market has immense potential to improvise its existing technology and replacing it with smart and innovative techniques to enhance customer count and make the process much more user friendly, efficient, and time saving. If the suggested techniques of the research paper are adopted by the leading manufacturing firms of vending machines, there could be a revolutionary chain of events which could benefit both, the technology and the vending machines.

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