Technical Forum

Advancing Intelligent Vending with the Internet of Things



Performance and Profits Improve with Building Block Solutions, Remote Management and Analytics

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Executive Summary

Connected embedded platforms, also known as intelligent systems, are transforming businesses, enabling them to take advantage of the Internet of Things (IoT). These intelligent systems improve all types of industrial applications, including the vending industry, which benefits from systems that are networked and communicating to gather and share information that enables insight and solves problems. Intelligent vending employs software, hardware and end-user applications that work together in real-time to unlock data that was previously hidden, creating smart, interactive points-of-sale. The addition of cloud-based remote management tools enables vending systems to be managed more effectively as a fleet of machines, not only creating a more powerful purchasing experience, but also eliminating the need for vending OEMs to guess at maintenance or restocking requirements.

Capitalizing on ADLINK's building block solutions, vending OEMs and system developers can reduce the total cost of maintenance, easily monitor and manage inventory status, and explore the value of Big Data with sophisticated cloud services. This white paper offers a closer look at how ADLINK's standard-based solutions help accelerate development of connected vending systems and applications, delivering on the promise of connectivity, cloud services and business analytics.

Modern day vending machines have been around for decades, delivering snacks and sodas at the push of a button. But today these simple machines are getting much smarter, thanks to a sea change enabled by the Internet of Things (IoT), a new world of connected devices that share real-time data in meaningful ways. The basic promise of an IoT-connected vending machine is remote maintenance and inventory status, as well as the ability to more closely track incoming revenue. But with the right embedded technology, smart vending machines will also dispense data in addition to the service or product sold. They'll track consumption, reconfigure in-machine currencies during shipment to their installation country, respond to gesture control or smartphone-like touch UIs, track users' eye movements or facial expressions, and serve up context-aware advertisements for the machine's products and other services like movies or music downloads.

Software updates and maintenance costs of a vending machine park can easily run as high as $200,000 a year, with a predicted lifetime of 5-7 years. By creating smart, connected machines, costs can be lowered by as much as $150,000 per year in reduced maintenance, optimized inventory, upselling products, firmware and GUI changes, or even consumer demographics used or sold to other ventures. In fact, the whole supply chain can be positively affected, the key driver creating big demand for a vending machine industry revolution. Eyeing these big numbers, vending operators are seeing the value that comes from more sophisticated embedded hardware and software – from high-res cameras for machine vision facial or gesture recognition, multiple smartphone-like touch screens with 1080p graphics, to wireless and NFC connectivity, to the latest high performance, low power processors implemented in rugged IoT boxes.

The transformation to intelligent vending is not simple, but is being addressed with new standards-based building block solutions from ADLINK, paving the way for new system development, as well as painless upgrades to legacy machines. ADLINK's off-the-shelf IoT solutions today incorporate world-class security and automated agents for easy set-up of devices; flexible and ready-made communications gateways; and a broad analytics infrastructure to help universally realize the greatest value from customer and machine data. Vending machine operators utilizing ADLINK's embedded building blocks and Smart Embedded Management Agent (SEMA) Cloud service can perform repairs, maintenance and upgrades within a single centralized operation. SEMA Cloud allows for remote monitoring of machine status, diagnosis of problems, and complete system management from anywhere, at any time, over the Internet. The overall impact on business operations is significant, including greater profitability resulting from higher sales and lower operating costs.

ADLINK's key solution building blocks cover all aspects of intelligent vending.

Intelligent vending machines, based on an ADLINK solutions such as single board computers (SBCs), modular or custom platforms, generate machine data, collect information about peripherals, and support remote management, control and configuration.

ADLINK intelligent gateways integrating the Intel® IoT Gateway platform to aggregate data from multiple vending machines and connect securely to the cloud over the Internet.

ADLINK Smart Embedded Management Agent (SEMA) Cloud Solution enables edge-to-edge cloud integration, and supports cloud-based management of vending machines and real-time monitoring of machine data.

ADLINK SEMA Cloud API exports machine data and control points for use by external applications.

ADLINK SEMA Portal provides system managers easy access to data and analytics through a cloud portal, using any device such as a desktop PC, tablet or smartphone.

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Creating Intelligent Vending Platforms

Replacing the historically limited performance of the Video Machine Controller (VMC) with more powerful embedded control and monitoring solutions ultimately creates the platform for intelligent vending. ADLINK's range of small form factor platforms include a vending machine I/O (VMI) board that integrates the Intel® Reference Design for Intelligent Vending as a means of accelerating development. Standards-based form factors such as COM Express®, Qseven or SMARC® computer-on-modules or PC/104, PCI-104 single-board computers (SBC) and Mini-ITX motherboards make ideal compute hubs for controlling the machine. Each provides a standards-based design path for VMC function, as well as modern intelligent vending performance, including appropriate control of more sophisticated peripherals to round out the system and an effective user interface.



Figure 1. All of ADLINK's computer-on-modules support Smart Embdedded Management Agent (SEMA) device-to-cloud remote management functionality. The Express BL is a COM Express Basic Size Type 6 module with 5th generation Intel® Core™ and Xeon®processors, with up to 32GB dual channel DDR3L at 1600MHz and an option for an Extreme Rugged™ operating temperature range of -40° to +85°C.

For example, using ADLINK's cExpress-BL Compact COM Express® Type 6 module, vending developers can access up to 16 GB DDR3L SDRAM and support up to three independent displays in a design rated for extreme rugged operating temperatures of -40°C to +85°C. Or for lower power requirements, the LEC-BT SMARC® full size module with Intel® Atom™ processor E3800 series system-on-chip offers thermal design power (TDP) as low as 5W and includes eMMC and camera interface to capture customer interaction.



Figure 2. SMARC is a versatile, small form factor computer-on-module definition targeting applications that require low power, low costs, and high performance. The LEC-BT is a full size SMARC module with Intel® Atom™ processor E3800 series SoC, up to 8 GB DDR3L at 1066/1333 MHz (ECC), and supporting a variety of I/O.

Alternatively, an all-in-one Intel® processor-based SBC, which may reside inside a panel PC, communicates to in-machine peripherals and sensors via a local bus. Choices include a multi-drop bus (MDB), CAN bus, or even I^2C or SPI (depending upon peripheral and sensor speeds). If additional local intelligence is required, such as for multiple graphics controllers or signal processing for machine vision (facial recognition or gesture control), I/O boards can be added and connected to the SBC via inter-board connections such as PCI Express.

In addition, ADLINK's Mini-ITX embedded board is with compact size, high-level processing and graphics performance with low power consumption. It delivers optimum computation performance required for system operation, peripheral subsystem control, and user interface. In addition, it also provides I/O flexibility (USB 2.0, Ethernet, and PCI express) and supports several display types, including HDMI, DVI, DisplayPort, SVDO, and VGA.



Figure 3. ADLINK's Mini-ITX computing platforms that are ready-for-use as commercial-off-the-shelf (COTS) solutions for infotainment and vending applications. The AmITX-HL-G features the 4th generation Intel® Core™ i7/i5/i3 desktop processor, dual SODIMM DDR3/DDR3L memory sockets supporting up to 16 GB, and support for up to three displays via DisplayPort.

ADLINK STC series smart touch computer provides a fully integrated building block display computer to manage all the requirements for the intelligent vending machines. It provides expansion capabilities to support payment options like NFC, security options with TPM and BIOS support. Remote manageability is supported through our use of the SEMA Agent board controller providing real time diagnostics of the board using WiFi or WWAN in remote locations. The STC supports scalability by providing a SMARC computer-on-module design to allow upgrade of different architectures for faster time to market.



Figure 4: The right computing platform is critical to any vending system. ADLINK's Smart Touch Computer series offers the power to control the entire vending machine, with the addition of a touch-based screen to support the needed user interface and rugged construction for steady operation in any environment.

If “local intelligence” is not established with 32-/64-bit Intel processors embedded in the machine itself, it may be handled close by in an ADLINK Intelligent Gateway device. This external Intelligent Gateway device can be interfaced to one or more legacy machines to provide the embedded processing needed, connecting to machines’ internal sensors via an internal I/O adapter board. Gateways are integrated, pre-validated solutions that streamline IoT application development, and securely connect these machines to the cloud. Based on the Intel® IoT Gateway, ADLINK’s family of platforms is designed to connect a wide range of devices; sitting in between the device and the cloud, they support an array of I/O interfaces necessary for the field bus or sensor network on the machine side of the equation, and deliver Internet connectivity via Ethernet, Wi-Fi or 2G/3G/4G connections on the cloud side.

ADLINK’s gateways are optimized for the IoT, built on open architecture to ensure interoperability between systems and solve the challenge of connectivity in an extremely compact footprint. The gateway design provides superior construction to withstand industrial grade EMI/EMS (EN 61000-6-4/EN 61000-6-2), making it a reliable embedded platform for use in vending machine applications. Scalable, low power options increase flexibility and are based on the Intel® Quark™ SoC X1000 series and Intel® Atom™ processor E3800 product family. Integration with the Wind River Intelligent Device Platform (IDP) provides easy access to a multi-protocol software stack. Developers can readily enable data forwarding and have a secure, manageable environment to execute application code.

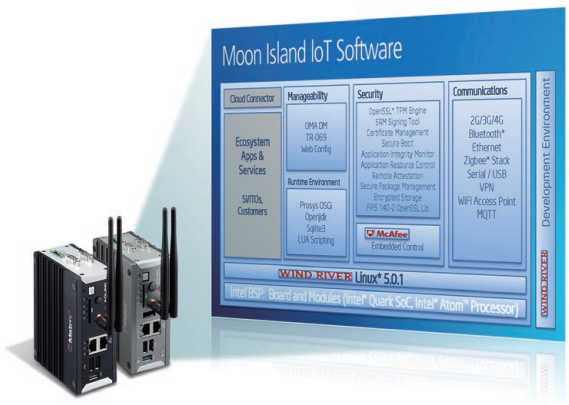


Figure 5: An example of an ADLINK Intelligent Gateway is the MXE-200i & MXE-100i. Integration with a Wind River operating system and middleware provides all critical elements to manage and communicate with IoT devices; developers are enabled with a sustainable and secure software development environment with pre-integrated components that are fully tested and ready-to-use in securing, managing and connecting intelligent gateways.

Reducing the High Cost of Maintenance

The addition of internal sensors to monitor the machine itself will benefit machine operators through predictive maintenance and remote diagnostics. For example, internal temperature monitoring can keep tabs on perishable products such as food, drinks, or any product that should remain within a specified temperature range in order to be “sellable.” Temperature sensors can also monitor the machine itself—at first activating local cooling fans, but also keeping tabs on mechanical assemblies, bearings, solenoids, and other moving parts. Similarly, resolvers, tachometers, and current-sensing devices measure increased power usage of internal sub-systems. Elevated temperatures and higher current draw can be indicative of future problems, and monitoring this data remotely allows an operator to predict eventual failures and schedule service prior to a catastrophic event.

But more important is the software that connects the machine’s myriad sensors and controllers, aggregates that data for upload to the cloud, and can allow easy parsing and remote interpretation for payment, data analytics, maintenance, and inventory decision making. ADLINK’s smart embedded management agent (SEMA) and SEMA Cloud platform provides the kind of embedded and cloud-based communications required by IoT-enabled smart vending machines. The software is a significant part of making a vending machine “smart” because it is designed to cope with IoT data and situation context.

Two components of the system, the SEMA Agent itself and SEMA Cloud intelligence, work together to send and receive real-time data used to enable more sophisticated vending machine operations. The SEMA Agent routinely collects data from an onboard board management controller (BMC), including statistics related to system uptime such as fan speed, power consumption and CPU temperature, and sends it on to the SEMA Cloud server; it also receives instructions from the SEMA Cloud, taking appropriate action to automatically initiate system management functions.

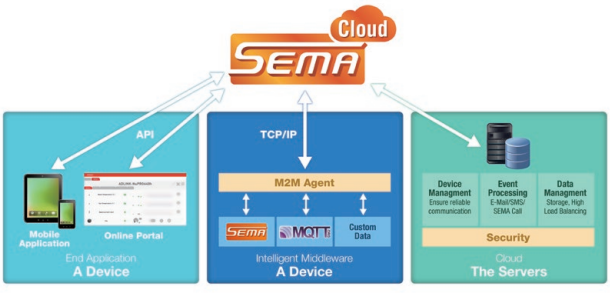


Figure 6: The SEMA agent runs locally in the embedded systems, either resident inside the newly designed vending machine, or in an Intelligent Gateway device. The agent, which is running in a separate Board Management Controller (BCM) in parallel with the CPU, is responsible for monitoring key system parameters such as temperature, fan speed(s), CPU load, and others. The agent can also handle a remote reboot and even an in-field firmware upgrade—something a local CPU can’t easily do alone. ADLINK’s SEMA architecture also works with a variety of emerging machine-level IoT protocols such as MQTT and others.

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SEMA Cloud is essentially the service backend for data and device management, including remote monitoring and control of vending machines. Using a flexible web dashboard, available as an element of SEMA Cloud or as part of the end-user's own IoT application, users can quickly access device status and activity logs. This data is securely exchanged behind a firewall and stored for business queries and visualization. Detection and alerting are based on user-defined rules and thresholds. As needed, operators can initiate machine management functions such as restart, software updates and diagnostics. The data from many machines can tell operators which machines need to be visited first and the most fuel-efficient routes for service trucks can be mapped; CPU temperature can be monitored for clues to machine performance and anticipated replacement of electronic components prior to failure. These functions can be programmed to sound an alarm to operators, as well as execute a preemptive action such as moving to backup battery in case of a pending failure.

SEMA Cloud also exposes a web-based API that enables programmatic access to SEMA capabilities. As a result, vending OEMs have a ready platform for device management, as well as the addition of external applications. OEMs can query the status of vending machines, group them together for performance updates, or define rules for alarms and automatic notifications. OEMs can develop their own strategic external applications that retrieve vending machine data for processing – blending information with other internal data sources and ultimately applying Big Data analytic services such as predictive maintenance modeling.

A New Approach to Monitoring and Managing Inventory and Logistics

With smart vending machines, operators gain valuable insight into how vending machine customers are engaging with the machine and its products. While internal sensors can predict maintenance and service requirements, they can also arrange for suppliers to stock machines that need it most, instead of burning fuel in trucks on a pre-defined (and unnecessary) route. ADLINK's SEMA Cloud dashboard brings a variety of machine data for operator visibility, seamlessly transmitting data among the field, data center and logistics. Data from machines scattered about a city or country can be rolled up and examined—from internal temperatures to a chart of what products are selling best and where. Machines can report on their own needs for maintenance, as well as fresh inventory. Inventory can be detected by weight, and refrigeration of products can be monitored for ideal settings. Data on stock shortages can be automatically delivered simultaneously to data centers, logistics hubs, fleet managers and warehouse operations for quick and efficient action. SEMA solves the problem of maintaining inventory, based on data illustrating real-world user consumption. Costs are reduced, logistics are streamlined and the most popular products remain in stock, keeping happy customers coming back for more.

Machines can indicate purchases, as well as what was not purchased, providing greater insight into customer metrics and preferences such as products, services, digital signage and advertising. Connected machines can be tied to other corporate systems such as enterprise resource planning (ERP) and central pricing. A greater array of payment options furthers the value – purchasing options are no longer limited to the change in your pocket, and today credit and debit card shopping can be offered. Contactless methods of payment are options, as well; for example, users can capture a QR code or swipe a smartphone equipped with near-field communications (NFC) connectivity. All of these advances add to the ability to better track revenues and reduce the variables that lead to abandoned purchases and reduced sales.

Exploring the Value of Big Data with Cloud Services

Offsetting the cost of the hardware, software, and data connection is the opportunity for machine operators to sell more product, monetize consumer data (a la Google, Facebook, and others), and reduce maintenance and service costs. Cloud connectivity dashboards are where the machines' remote data realizes these goals. Once smart vending machines are in place, revenue creation and maximizing uptime will rely on massive amounts of data from a company's machines. Dispensing product—be it coffee, prescription medicine, or digital cameras—is only one part of the revenue stream for machine vendors. With built-in sensors and aggregated data from multiple machines, consumer demographics—from a person's age and gender to their individual buying habits—can be uploaded to the cloud for monetization.

Depending on the application, commands and data may be returned to the vending machine, enabling analytics applications to guide performance of the machine itself. For example, data from the cloud can be quickly sent to a machine to enhance the buying experience and encourage a consumer upsell. Smart machines can tailor their on-screen messages to each customer, relying on gamification for the proper engagement based upon the customer's age range. Younger customers may expect advanced graphics on multiple touch screens and will likely pinch, zoom, swipe, and even gesture in mid-air. Older, less computer-literate customers may need the message simplified with 2D buttons on a single screen. Intelligent vending machines are loaded with sensors and "smarts," and are capable of not only product sales but also engaging and entertaining the customer/user in the process.

Smart Vending Machines Are Smart Business

Reducing costs and opening up new business opportunities are key drivers fueling the growth of the intelligent vending market. With real-time cloud access to critical machine information, vending routes no longer need to be calendar-based, but instead can be predicted and managed dynamically. Maintenance activities become condition-based, using current data from the machine that identifies worn parts for replacement prior to failure. Inventory is managed more effectively, with the right products being restocked at the right time. At the same time, intelligent vending is a powerful new business model, offering customers a richer, more engaging purchasing experience. Smarter, more connected systems are creating new transaction and payment models, and transforming back-end business operations with cloud-based remote management, diagnosis and real-time business analytics. With embedded intelligence built into smart vending machines, plus cloud connectivity, all kinds of new scenarios become possible.



Figure 7: A recent Intel survey documented the value of intelligent vending. More than 61 percent of respondents acknowledged they would prefer a more fun and interactive vending experience; 62 percent expressed a desire for touchscreens, and 17 percent wanted to operate machines with simple hand gestures. With intelligent systems, vending OEMs reduce operating costs, simplify deployment, increase sales and have a path to new revenue streams from more sophisticated services based on authentic customer metrics. For vending OEMs and system designers, ADLINK's building block solutions and communications platforms – proven, rugged and secure from end-to-end – are accelerating development and bringing new competitive opportunities to the vending market.

ADLINK is a Premier Member of the Intel® Internet of Things Solutions Alliance. From modular components to market-ready systems, Intel and the 350+ global member companies of the Intel® Internet of Things Solutions Alliance provide scalable, interoperable solutions that accelerate deployment of intelligent devices and end-to-end analytics. Close collaboration with Intel and each other enables Alliance members to innovate with the latest technologies, helping developers deliver first-in-market solutions.

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About ADLINK Technology

ADLINK Technology is enabling the Internet of Things (IoT) with innovative embedded computing solutions for edge devices, intelligent gateways and cloud services. ADLINK's products are application-ready for industrial automation, communications, medical, defense, transportation, and infotainment industries. Our product range includes motherboards, blades, chassis, modules, and systems based on industry standard form factors, as well as an extensive line of test & measurement products and smart touch computers, displays and handhelds that support the global transition to always connected systems. Many products are Extreme Rugged™, supporting extended temperature ranges, shock and vibration.

ADLINK is a Premier Member of the Intel® Internet of Things Solutions Alliance and is active in several standards organizations, including PCI Industrial Computer Manufacturers Group (PICMG), PXI Systems Alliance (PXISA), and Standardization Group for Embedded Technologies (SGeT).

ADLINK is a global company with headquarters in Taiwan and manufacturing in Taiwan and China; R&D and integration in Taiwan, China, the US, and Germany; and an extensive network of worldwide sales and support offices. ADLINK is ISO-9001, ISO-14001, ISO-13485 and TL9000 certified and is publicly traded on the TAIEX Taiwan Stock Exchange (stock code: 6166).

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