Solution Blueprint
Internet of Things (IoT)

Improving Vending Machine Profitability with the Internet of Things (IoT)

Intel and ADLINK Technology* use IoT technologies to help vending machine operators reduce operating costs and increase sales.



ADLINK TECHNOLOGY INC.

Driving a data revolution in the vending industry

Executive Summary

The vending industry is undergoing a sea change, taking advantage of new technologies to go beyond just delivering snacks to creating a new retail location. Intelligent vending machines can be found in many public locations as well as company facilities, selling different types of goods and services, including even computer accessories, gold bars, tickets, and office supplies. With increasing sophistication, they may also provide time- and location-based data pertaining to sales, inventory, and customer preferences.

But at the end of the day, vending machine operators know greater profitability is driven by higher sales and lower operating costs. Addressing these priorities, Intel and ADLINK Technologies* are delivering products and services based on the Internet of Things (IoT), which refers to billions of Internet-connected devices ranging from industrial sensors to pedometers. This paper details a vending machine management and data analytics solution that connects a fleet of machines to the cloud-based tools that can help generate more revenue and reduce maintenance effort.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Table of Contents

Executive Summary 1
Key Business Objectives 2
Business Challenge 2
Solution Benefits 2
Solution Overview 2
Technology 4
Creating a Connected Vending Machine 6
IoT Tenets 7
Summary 8
Resources 8

Key Business Objectives

Increasing the profitability of vending machines using big data and remote management tools to reduce the cost of operating a fleet of machines and generate more revenue.

Business Challenge

Vending machine operators have traditionally endured considerable expense and inconvenience in their efforts to maintain, repair, and upgrade vending machines without a centralized administration system to perform these functions. Maintenance and support costs are high because on-site visits are often required in order to do software upgrades, troubleshooting, and repairs. Moreover, revenue is lost whenever a vending machine is out of order, a situation made worse when it takes days to discover and resolve the problem.

Another concern is being able to attract and engage younger customers who are often preoccupied with their smart phones and accustomed to an always-connected world. Trying to appeal to this demographic, leading product manufacturers, like Pepsi*, are pioneering their own highly intelligent vending machines with others in the industry following suit. However, incorporating new technologies like big data, the cloud, gamification, geofencing, etc, is not easy, and requires most vending machine manufacturers and operators to seek out some help.

Solution Benefits

Through the use of IoT technologies and big data analytics, ADLINK and Intel have enabled a new breed of connected, intelligent vending machine that offers the following benefits:

- **Lower Operating Costs**
  Cloud connectivity enables vending machine operators to diagnose and repair systems remotely, thereby reducing machine downtime and on-site maintenance costs. Vending machines can also send real-time updates (e.g., supply and operating status) that can be used to optimize delivery schedules and logistics, and improve inventory tracking and control.
- **Simplified Deployment and Operation**
  The solution's middleware and cloud service is scalable and secure, helping to streamline edge-to-cloud integration, lower deployment cost, and speed up end-to-end application development.
- **Increased Sales**
  The cloud makes it easier to implement promotional strategies for increasing transaction size and sales volumes, like gifting, dynamic pricing, vouchers, coupons, and loyalty programs, which is virtually impossible with conventional vending machines.
- **New Revenue Streams**
  Vending machine operators can generate incremental revenue from product manufacturers who want to show directed advertisements to customers and encourage repurchases by sending coupons to their mobile phones.

Solution Overview

Intel and ADLINK have applied Internet of Things (IoT) technologies to connect vending machines to cloud-based remote machine management and business analytics. This vending machine management and data analytics solution is designed to reduce operational expenses and improve business efficiency, while being scalable, easy to deploy, and simple to operate.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

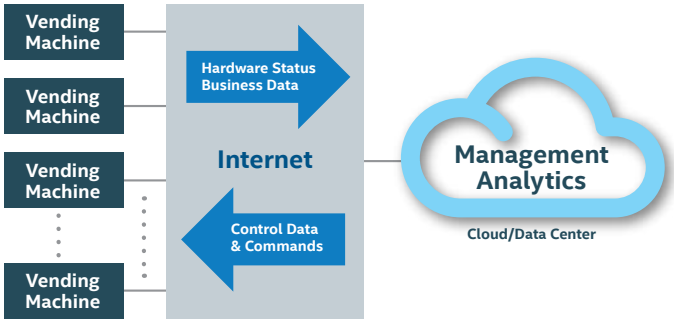


Figure 1. Simplified Representation of Cloud-Connected, Intelligent Vending Machines

As illustrated in Figure 1, a fleet of vending machines periodically sends updates about hardware status and business data to the cloud, and management analytics software running in the cloud sends control data and commands back to the machines. The machine data can be mined for useful information and further analyzed to generate relevant insights, predict consumer trends, and support business decisions.

High-Level Architecture

Figure 2 shows the end-to-end architecture of the vending machine management and data analytics solution based on hardware, software, and cloud technologies from Intel and ADLINK. Using this solution, new or legacy vending machines can be connected to the Internet via broadband or wireless connectivity.

Vending machine data are aggregated by IoT gateways and stored in the cloud, where the data can be accessed via web-based portal or retrieved by external applications for analytics purposes. Cloud applications also send commands and data to remotely manage, control, and configure the vending machines. This includes capabilities to do remote diagnostics on individual vending machines as well as push software updates to the entire fleet.

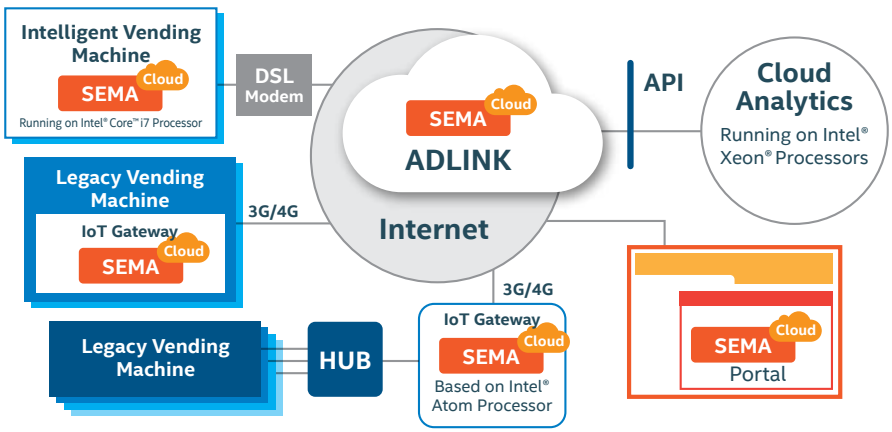


Figure 2. High-Level, End-to-End Architecture

The key solution building blocks are:

- **Intelligent vending machines** based on an ADLINK solution: single board computer (SBC), modular, or custom
  - Generate machine data, collect information from peripherals, and support remote management, control, and configuration.
- **ADLINK IoT Gateways** based on Intel® Gateway Solutions for the Internet of Things (Intel® Gateway Solutions for the IoT)
  - 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-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 desktop PC, tablet, or smartphone.

Vending machine operators utilizing ADLINK's embedded building blocks and SEMA Cloud service can perform repairs, maintenance, and upgrades with a single centralized operation. SEMA Cloud allows for remote monitoring of machine status, diagnosis of problems, and complete system management from anywhere, at anytime, over the Internet.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

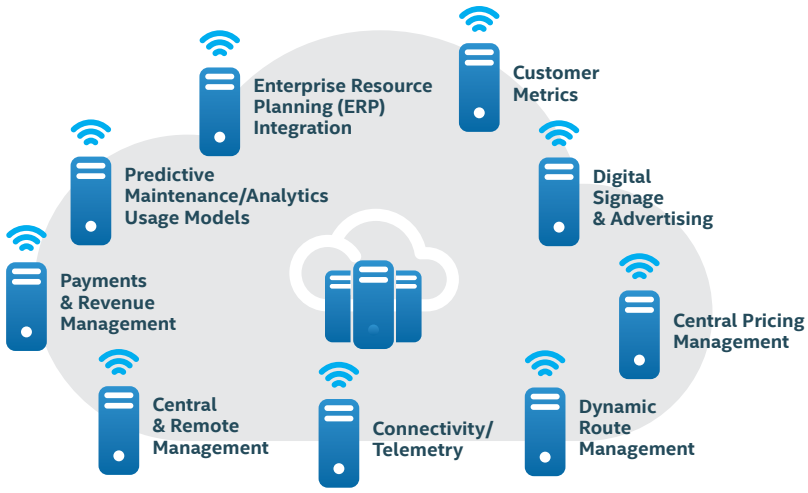


Figure 3. Examples of Cost Reduction and New Business Opportunities Enabled by the Internet of Things

Example Usage Models

Connecting intelligent vending machines to cloud-based applications opens the door to many cost reduction and new business opportunities, including those represented in Figure 3.

1. **Digital Signage and Advertising**
   By taking advantage of new technologies, each vending machine can now become an intelligent system that offers a richer, more engaging customer experience, whether it is selling soft drinks or services. Sixty one percent of respondents to an Intel survey[1] said they would like their vending experience to be more interactive and fun, with 62 percent expressing a desire for touch screens, and 17 percent wanting to operate machines using hand gestures.
2. **Customer Metrics**
   Some of today's machines not only "know" what was purchased, but what was looked at and not purchased, giving product manufacturers and operators more insight into the drivers of sales and customer satisfaction. They are also detecting and messaging specifically to individual patrons with directed advertisements based on their demographics.
3. **ERP Integration and Predictive Maintenance**
   Vending machine operators can automate and streamline their business by tying machines to corporate systems, such as Enterprise Resource Planning (ERP) and central pricing. Intelligent machines can potentially save cost by accessing cloud-based services, for example, dynamic route management condition-based maintenance, which identifies excessively worn parts so they can be replaced before they fail.
4. **Payment and Revenue Management**
   The vending industry needs no longer rely on customers to have cash in their pockets. Intelligent vending machines deliver more payment options, like credit and debit cards, QR codes, swiping a phone using near field communications, and other contactless payments methods.

   In much greater numbers, shoppers will conduct transactions for goods or services made by scanning, tapping, swiping, or checking in with a mobile phone at the point of sale. A recent eMarketer study projects mobile payment transactions in 2016 will reach $26.5 billion (USD), more than 25 times the slightly over one billion in 2013.[2]

Technology

This section describes the technology ingredients available to deploy a vending machine management and data analytics solution.

Computing Solution for Intelligent Vending

At the heart of every intelligent vending machine is an embedded computer controlling and monitoring machine operation. These functions can be fulfilled with an ADLINK SBC (e.g., Mini-ITX and PC/104) or Computer-on-Module (e.g., COM Express, SMARC, Qseven, and ETX) featuring an Intel® Core™ processor that delivers computation performance required for system operation, peripheral subsystem control, and user interface.

This low-power processor also provides I/O flexibility (USB 2.0, Ethernet, and PCI Express*) and supports several display types, including HDMI, DVI, DisplayPort, SVDO, and VGA. It also supports error correcting code memory and enhanced graphics.

ADLINK computer boards are equipped with an ADLINK board management controller (BMC) chip that supports board-level management and control functions. The BMC collects statistics and measurements (e.g., CPU temperatures and fan speed) pertaining to system uptime and power consumption, which are accessible from the main processor via SMBus interface.

IoT Gateway

Based on Intel Gateway Solutions for the IoT and the Intel® Atom™ processor, the ADLINK MXE-200i Series IoT Gateway* is a fully integrated and optimized hardware and software system for connecting machines to the cloud over the Internet. It supports

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

I/O interfaces to field bus or sensor network on the machine side, and the Internet over Ethernet, Wi-Fi, or 2G/3G/4G connectivity on the cloud side. Based on the Wind River* Intelligent Device Platform (IDP), it includes a multi-protocol software stack for data forwarding and provides a manageable and secure run-time environment for code execution. An Intel® architecture processor in the ADLINK IoT Gateway delivers the computation power required by intelligent gateway applications to perform local data aggregation, transformation, and analytics.

Cloud Support

ADLINK Smart Embedded Management Agent (SEMA) Cloud Solution provides machine-to-cloud integration and management services. It consists of two interworking components: SEMA Agent and SEMA Cloud intelligence. Running on end-devices or gateway platforms, the SEMA Agent maintains communication with SEMA Cloud servers on the Internet. The agent's main function is to periodically collect and send data updates from the on-board BMC, other hardware components, and software applications to the SEMA cloud. The agent also receives commands and data from the SEMA cloud and takes action as required.

SEMA Cloud is the service backend for data and device management, which includes remote monitoring and control of vending machines. Via a web dashboard, users can access information such as device status and activity logs as well as initiate machine management functions, including restart, software updates, and diagnostics. Data received from vending machines is stored in a database, from which it can be queried and visualized. SEMA Cloud also supports event detection and alerting based on user-defined rules and thresholds.

Message exchange and data transfer between SEMA Agent and SEMA Cloud are conducted using the HTTPS protocol and a standard TCP port. As such, agent-to-cloud communication can occur behind firewalls.

the memory capacity of the previous generation, the Intel Xeon processor E7 v2 family lends itself well to supporting in-memory computation. A very large dataset can be accommodated in system memory: up to 6 TB on a four-socket system and 12 TB on an eight-socket system.

A summary of the previously discussed solution ingredients is shown in Table 1.

BUILDING BLOCKS CATEGORY	ADLINK* OFFERINGS	INTEL COMPONENTS
Single Board Computers for Intelligent Vending Machines	Mini-ITX, PC/104	Intel® Core™ or Intel® Atom™ processors
Computer-On-Modules for Intelligent Vending Machines	COM Express: Express-HL, etc. SMARC: LEC-BT, etc. Qseven: Q7-BT, etc. ETX: ETX-BT, etc.	Intel® Core or Intel Atom processors
IoT Gateway Products	MXE-200i Ultra Compact Embedded Platform*	Intel® Gateway Solutions for the Internet of Things
Device/Machine Cloud Service	SEMA* Cloud	Intel® Xeon® processors

Table 1. Summary of ADLINK* Intel Products for Vending Machine Management and Data Analytics

Cloud Computing Platform

Servers based on the Intel® Xeon® Processor E7 v2 family are used to run computationally and I/O intensive software algorithms used for predictive modeling and business intelligence. Delivering the performance required for fast and efficient execution of these types of workloads, this processor family is built with Intel's 3D Tri-Gate transistor technology. It offers twice the performance of the previous generation. It also achieved a fourfold improvement in I/O via support of Intel® Integrated I/O, Intel® Data Direct I/O Technology, and PCI Express.

Real-time monitoring for failure recognition, event detection, and feedback control demands fast and thorough processing of streaming data. This requires in-memory computation – program execution with the entire dataset loaded in system memory with minimal disk-IO transfers. With triple

Cloud API

The SEMA Cloud exposes a web-based API to enable programmatic access to SEMA capabilities. The API supports two sets of functions for device management and for external applications to query the status of individual vending machines, create groupings, and define rules for alarms and notifications. It also supports data access and control.

External applications can retrieve vending machine data for processing, analysis, mashup with other data sources, and big data services such as predictive maintenance modeling. External applications may also send commands and data back to vending machines, thus allowing analytics applications to exercise feedback control and take data-driven actions. Therefore, SEMA Cloud's API service is key to adding value and building intelligence on top of SEMA's base capabilities.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

IoT solutions for vending machine management and data analytics can help vending machine operators reduce operating costs and increase sales. ADLINK and Intel provide the enabling technologies and building blocks for these solutions.

End-to-End Security

This solution integrates a number of security mechanisms to secure data transfers from vending machines to the cloud.

- Secure Boot and Intel® Trusted Execution Technology (Intel® TXT)[3] supported by Intel® processors protects vending machines and gateways during the boot process and before other software-based solutions begin to execute.
- McAfee* Embedded Control maintains the integrity of vending machines by allowing only authorized code to run and only authorized changes to be made. It automatically creates a dynamic whitelist of the "authorized code" on the system. Once the whitelist is created and enabled, the system is locked down to the known good baseline, and no program or code outside the authorized set can run. Whitelisting helps to prevent viruses, spyware, worms (like the Stuxnet worm), and other malware from executing.
- Transport Layer Security (TLS) protects data and control messages sent between the SEMA agent and the SEMA cloud.
- Dashboard access requires login credentials, and SEMA Web API invocation is controlled via authorization and authentication.

Data Analytics

Intel® Retail Client Manager (Intel® RCM) gives product manufacturers and operators valuable insights into how vending machine customers are responding to visual messaging and how they are engaging with the machine and its products. The software aggregates viewer statistics by gender, age range, impression counts, and dwell times, information that can be used to play directed advertisements and measure campaign effectiveness, as well as determine lost sales from customers who walked away without making a purchase. This is all done anonymously and while respecting viewer privacy.

Creating a Connected Vending Machine

The following describes ways to make a vending machine intelligent, starting with either a new or legacy design.

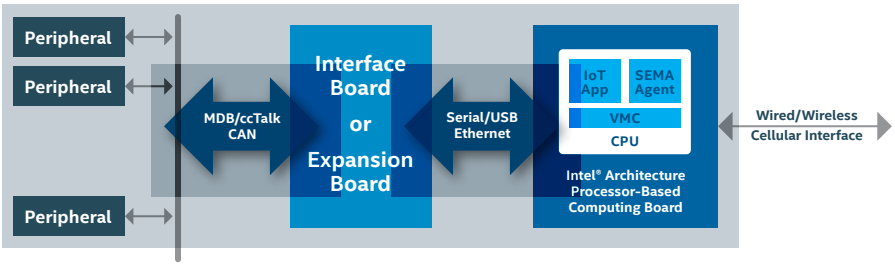


Figure 4. Intelligent Vending Machine Based on a New Design

New Design

Equipment developers can design an intelligent vending machine using an ADLINK computing board based on an Intel architecture processor, as shown on the right hand side of Figure 4. The SBC is connected to an expansion board, which interfaces with vending machine peripherals via an internal bus, such as a multi-drop bus (MDB), ccTalk, or CAN bus. With network connectivity built into the computing board, the vending machine can be IoT-enabled by adding two interworking software components to the computing

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

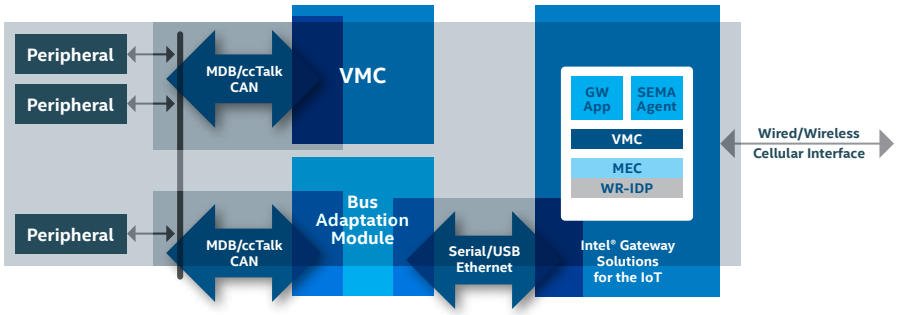


Figure 5. Intelligent Vending Machine Based on a Legacy Design

board: an IoT application and the SEMA agent. The IoT application gathers machine data from the peripherals and passes them to the SEMA agent for transmission to the SEMA Cloud. The vending machine is also responsible for taking any actions as prescribed by commands and data received by the SEMA agent from SEMA Cloud.

Legacy Design

On legacy vending machines, peripherals are monitored and controlled by finite state machine firmware running on a vending machine controller, with communication enabled via one or more bus protocols (e.g., MDB, ccTalk, or CAN bus). These vending machines can be IoT-enabled via integration of the Intel Gateway Solutions for the IoT. Gateway-to-machine integration can be one-to-one or one-to-many. In one-to-one integration, the Intel Gateway Solutions for IoT is retrofitted into a legacy system using a bus adaptation board, which interfaces to the system bus on one side and connects to the gateway via a serial or USB port on the other side. The IoT Gateway's runtime will include two interworking software components:

1. SEMA agent which connects to SEMA cloud
2. IoT application, which handles data collection and remote control

Optionally, the vending machine control logic can be ported to run on the IoT gateway, thereby allowing the elimination of the original vending machine controller.

In one-to-many integration, a single IoT gateway device is used externally to provide cloud connectivity to a group of co-locating vending machines. This requires installation of a bus adaptation board on each vending machine in the group, and the use of a hub device to interconnect the adaptation boards to the IoT gateway. The IoT application running on the gateway is responsible for acquiring data and effecting control on each of the vending machines. The SEMA agent runs alongside to communicate with the SEMA Cloud.

IoT Tenets

The vending machine management and data analytics solution by ADLINK and Intel is designed to provide security and interoperability from edge to cloud in keeping with five key tenets defined by Intel:

- **World-class security** as the foundation
  - The solution protects the entire manufacturing environment with state-of-the–art security solutions.
- **Automated discovery and provisioning of edge devices** to ease deployment
  - The ADLINK SEMA cloud supports easy setup with ADLINK IoT gateways and End Systems running ADLINK SEMA agent.
- **Data normalization** through protocol abstraction to improve interoperability
  - The ADLINK IoT gateway maintains various device and communication protocols.
- **Broad analytics infrastructure** from edge to cloud to realize customer value
  - The ADLINK SEMA Cloud can potentially interwork with various data analytics software, including Intel RCM that measures customer responses to advertising.
- **Infrastructure** to monetize hardware, software, and data management from edge to cloud
  - The ADLINK SEMA cloud can potentially interwork with revenue generating services, such as playing advertisements on vending machines.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Improving Vending Machine Profitability with the Internet of Things (IoT)

Summary

IoT solutions for vending machine management and data analytics can help vending machine operators reduce operating costs and increase sales. ADLINK and Intel provide the enabling technologies and building blocks for these solutions. This includes ADLINK embedded devices based on Intel processors that satisfy the performance, connectivity, and security requirements of executing data collection and remote control tasks on intelligent vending machines. This also includes ADLINK IoT gateways, based on Intel Gateway Solutions for the IoT, which can be used to reliably connect legacy vending machines to the Internet and support secure communications with cloud servers.

In addition, ADLINK SEMA middleware and cloud services help simplify edge-to-cloud integration, lower deployment cost, and accelerate end-to-end application development. Computation demanding and I/O intensive cloud software can run on Intel Xeon processor-based server platforms, which deliver the processing power and memory performance required by big data applications and real-time analytics. The total solution provides an end-to-end IoT architecture for vending machine operators looking to improve profitability by harnessing the power of data.

Resources

Intel® Internet of Things Solutions Alliance
Members of the Intel® Internet of Things Solutions Alliance provide the hardware, software, firmware, tools, and systems integration that developers need to take a leading role in IoT.

Intel® Gateway Solutions for the Internet of Things Development Kits
Intel® Gateway Solutions for the Internet of Things development kits enable solution providers to quickly prototype, develop, and deploy intelligent gateways. Available for purchase from several vendors, the kits also maintain interoperability between new intelligent infrastructure and legacy systems, including sensors and data center servers.

For more information about ADLINK Embedded Computing Solutions, visit **www.adlinktech.com/ccps.**
For more information about ADLINK SEMA Cloud, visit **www.adlinktech.com/sema**

Learn more about Intel Retail Solutions for the Internet of Things at **www.intel.com/retail.**
Learn more about Intel Gateway Solutions for the Internet of Things at **www.intel.com/iot.**

[1] The Smart Vending Survey is based on data collected by Redshift Research - an independent market research company. Online interviews were used to collect responses across eleven countries within EMEA and the USA, with 6,018 individuals surveyed in total. The European countries surveyed were: France, Germany, Italy, Netherlands, Poland, Russia, Spain, Sweden, Turkey, UK and Ukraine. Fieldwork was completed in October 2012.

[2] US Mobile Payments to Top $1 billion in 2013." eMarketer. July 11, 2013, www.emarketer.com/Article/US-Mobile-Payments-Top-1-Billion-2013/1010035.

[3] No computer system can provide absolute security. Requires an enabled Intel® processor, enabled chipset, firmware, software and may require a subscription with a capable service provider (may not be available in all countries). Intel assumes no liability for lost or stolen data and/or systems or any other damages resulting thereof. Consult your Service Provider for availability and functionality. For more information, visit http://www.intel.com/go/anti-theft . Consult your system manufacturer and/or software vendor for more information.

INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH INTEL® PRODUCTS. NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. EXCEPT AS PROVIDED IN INTEL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, INTEL ASSUMES NO LIABILITY WHATSOEVER, AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO SALE AND/OR USE OF INTEL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. UNLESS OTHERWISE AGREED IN WRITING BY INTEL, THE INTEL PRODUCTS ARE NOT DESIGNED NOR INTENDED FOR ANY APPLICATION IN WHICH THE FAILURE OF THE INTEL PRODUCT COULD CREATE A SITUATION WHERE PERSONAL INJURY OR DEATH MAY OCCUR.

Intel may make changes to specifications and product descriptions at any time, without notice. Designers must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." Intel reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The information here is subject to change without notice. Do not finalize a design with this information.

The products described in this document may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request. Contact your local Intel sales office or your distributor to obtain the latest specifications and before placing your product order. Copies of documents which have an order number and are referenced in this document, or other Intel literature, may be obtained by calling 1-800-548-4725, or by visiting Intel's Web site at www.intel.com.

Copyright © 2014 Intel Corporation. All rights reserved. Intel, the Intel logo, Intel Atom, Intel Core and Xeon are trademarks of Intel Corporation in the U.S. and/or other countries.

*Other names and brands may be claimed as the property of others. Printed in USA 1214/MS/CS/SD/PDF ♻ Please Recycle 331651-001US

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000