Networked Smart Gateways for Energy Management and Control

Nicholas Sargologos

Introduction

Governments worldwide are mandating improved energy efficiency, requiring an investment in the new smart grid and smart energy management structure. The goal is to create a smart grid that will change the way power is deployed for sustainable energy around the world. At the heart of the world-wide rollout of smart meters and the construction of a smart grid network infrastructure lays the goal of energy efficiency from the generation, transmission and distribution to the end customer.

Leveraging the deployment of communications-enabled electricity meters, many applications can be offered to home owners for optimizing overall energy management and to utility companies as a means of managing the load of their grid and preventing power demand peaks. The energy gateway is the interface between the utility-controlled smart grid and energy-consuming in-house objects.

Evolution of Networked Smart Gateways (NSG)

The smart grid device that enables utility companies to capture customer usage data is the smart meter, show in Figure 1 as a part of the home automation network (HAN) on the left side of the diagram. The evolution of smart meters has been incremental, beginning with the integration of short range RF technologies that allowed "drive-by" capture of meter readings, which saved time and improved accuracy.

Next, smart meter improvements followed that eliminated the need for a mobile field staff to capture meter data. This latest round of smart meter improvements has been based on standards-based communication technologies driven by the Advanced Metering Infrastructure (AMI) organization.

"The average cost of saving a kilowatt-hour through efficiency is 1.7 cents per kilowatt-hour; the cost of generating any new kilowatt-hour of electricity today would be over 10 cents per kilowatt-hour—so the cost savings generated through efficiency are spectacular"

John Bryson
Chairman and CEO of Edison International

Figure 1: Networked Smart Gateways Multi-Application Support

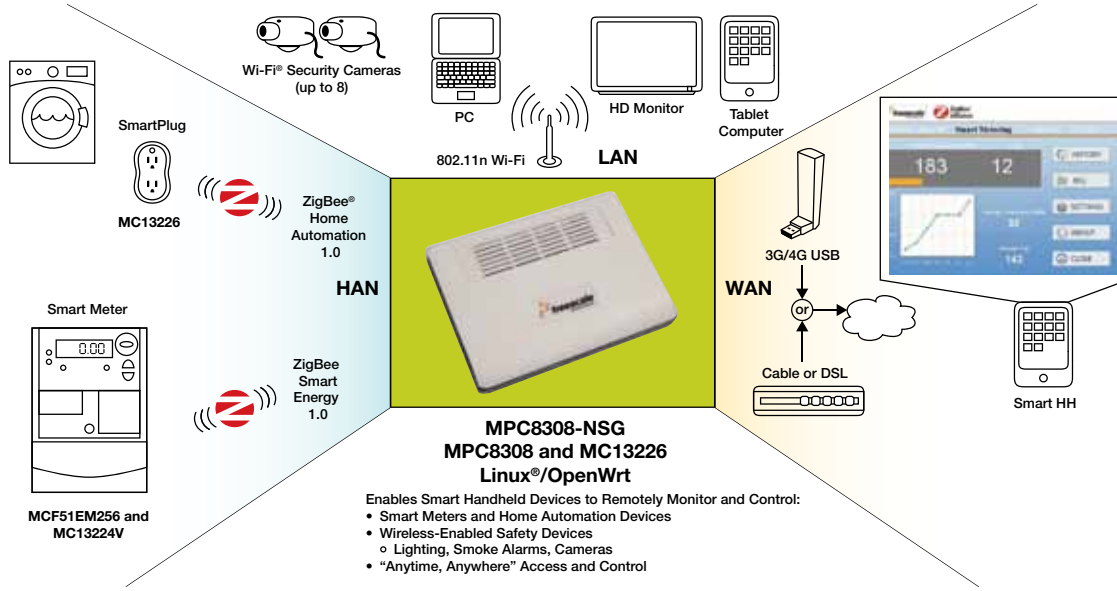


Figure 2: Freescale's Networked Smart Gateway Reference Design

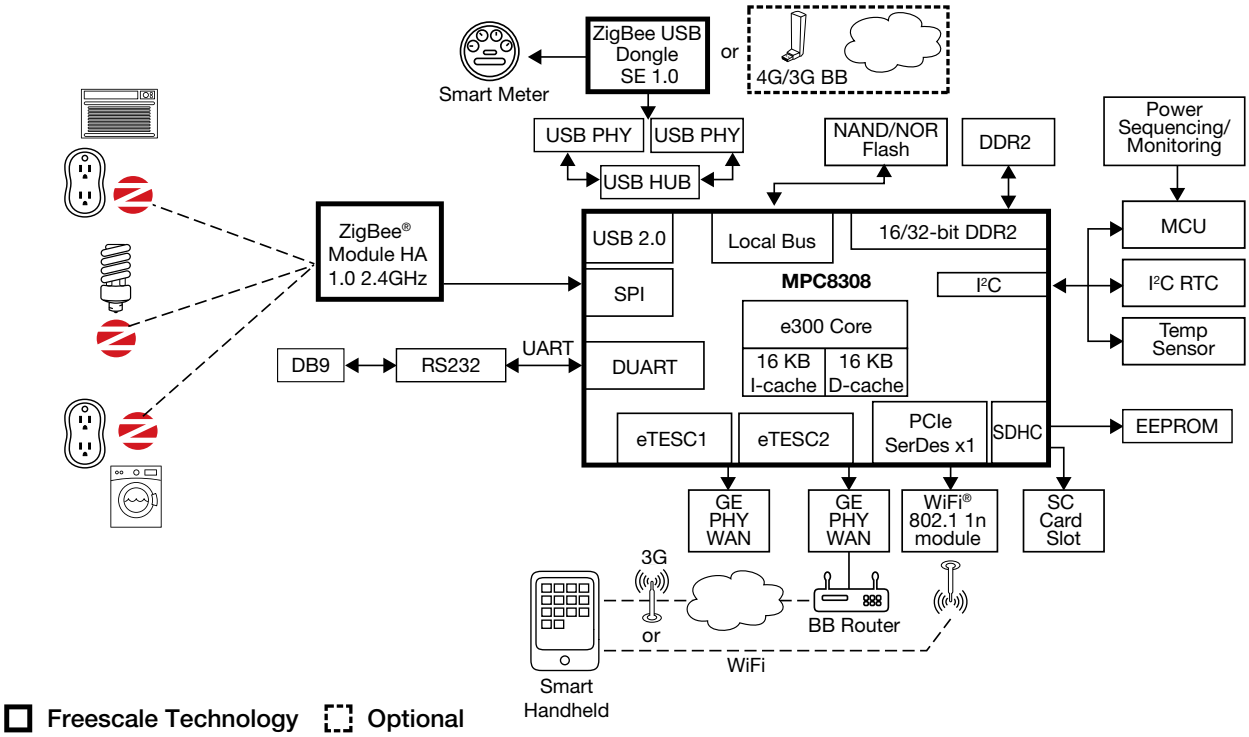
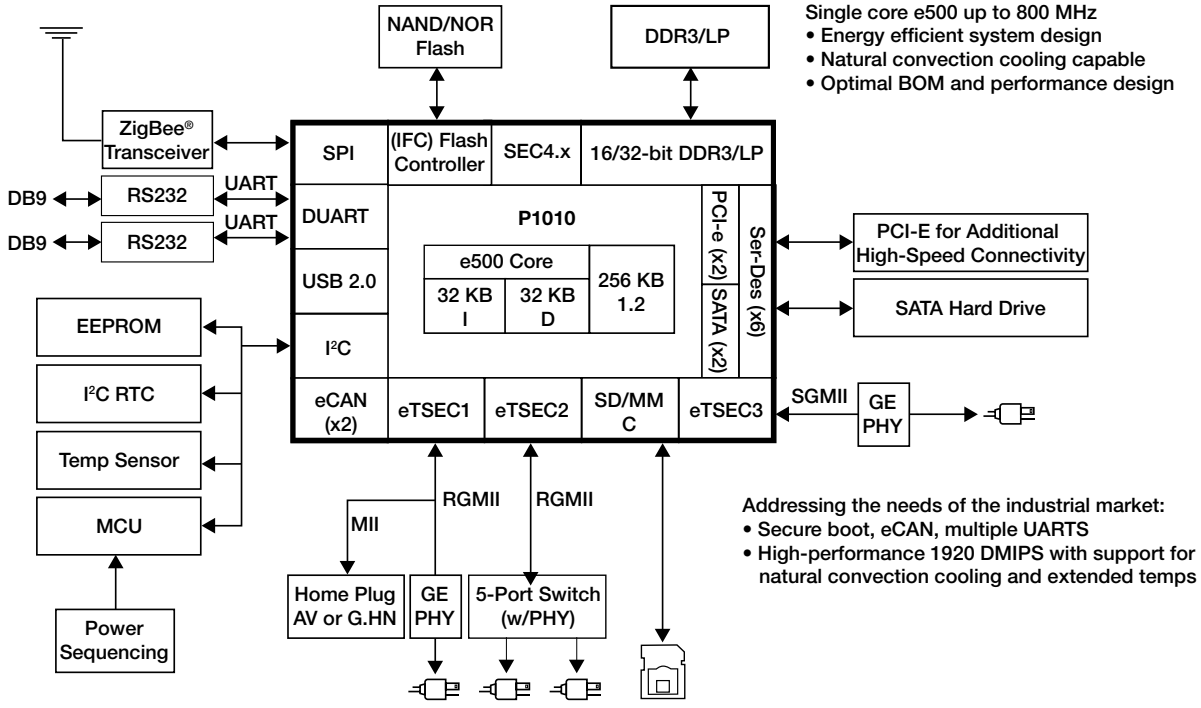


Figure 3: Freescale Energy Gateway Solution Using the QorIQ P1010 Processor



The use of standards-based communication technologies has opened the door for existing home-networking platforms, such as residential gateways and broadband AP routers, to incorporate connectivity support. This new class of platform is referred to as a "smart energy gateway," or alternatively, a "networked smart gateway (NSG)" and represents the heart of the HAN.

Key Benefits of Smart Energy Gateway or NSG

A smart energy gateway provides the necessary interface between the utility-controlled smart grid and energy-consuming in-house object. Some of the key benefits of the smart energy gateway solution are:

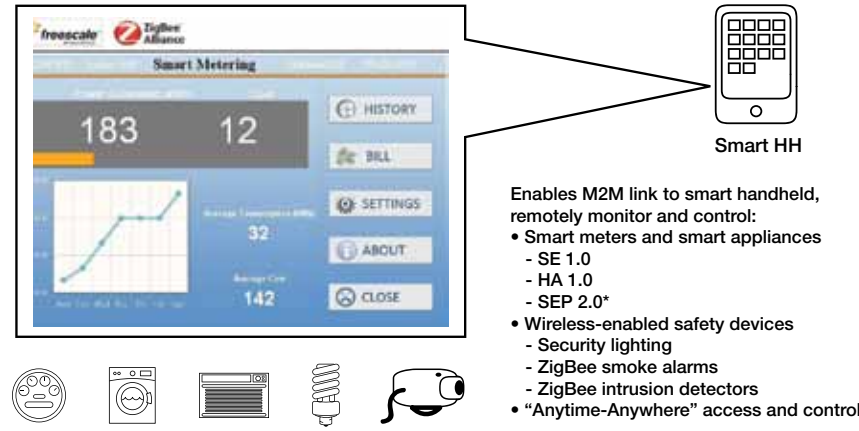
- Control activation/deactivation of HAN appliances
- Collect real-time energy consumption from smart meter and power consumption data from various in-house objects
- Generate dashboards to provide feedback about power usage
- Provide control menus to control appliances
- Provide a ubiquitous link to wide area network (WAN) for remote control/readout

Challenges in Implementing Smart Energy Gateway Solution

The key modifications necessary to enable a residential gateway to serve as a smart energy gateway is support for the PHYs and protocols that have been adopted for use in smart meters and home automation devices. The PHYs used in smart meters include: HomePlug Green PHY (Power Line Communication), ZigBee® technology and 802.11. The associated communication protocols include DLMS, Smart Energy 1.0, Smart Energy 2.0 (coming soon) and M-Bus in the European market. The integration of these PHYs together with support for communication protocols associated with them is a key requirement for designing a smart energy gateway. In parallel, these same PHY technologies are rapidly being adopted for use within the HAN to support home automation connectivity with appliances, lighting, security systems and health monitoring devices, as illustrated in Figure 1. This enablement is being guided by AMI as well as the Association of Home Appliance Manufacturers (AHAM), the USNAP consortium and HEMS Alliance. Other considerations that must be factored into smart energy gateway designs include backhaul support to WAN, and perhaps most importantly, a user interface (UI) that enables access, monitoring and control over the connected HAN devices.

This last factor deserves special emphasis. The ability to access, monitor and control devices within the HAN is an essential capability if consumers are going to successfully manage and conserve the energy they use. The UI must allow customers to see exactly how much energy they are using, how much the utility company is charging for that energy, and provide the ability to exercise control over HAN-connected devices, if necessary.

Figure 4: NSG's Graphical User Interface



Of equal importance to providing this UI is the ability to access it remotely, at any time, via a smart handheld device or tablet. This capability leverages the global preference by consumers to utilize a single smart device for all their communication applications, extending from voice, texting, email and entertainment to now include home monitoring, security and control.

Freescale's Smart Gateway Solution

Freescale's smart energy gateway solution is designed to address the challenges mentioned above. It can be designed either with Freescale's low-end processors, like the MPC8308 using an e300 core, or with Freescale's high-end processors, like P1010/P102x which uses an e500 core. Figure 2 and Figure 3 show a reference design for each of these solutions. This multi-functional energy gateway can support machine-to-machine (M2M) connectivity from smart handheld devices, such as smart phones or tablets, to HAN. Through this M2M connection, a user can remotely monitor energy usage, receive alerts from their utility company regarding billing or tariff changes, and manage the smart devices within his/her HAN. Due to this, it serves as a single-chip solution providing all necessary secure connections between end-to-end devices in smart grid network.

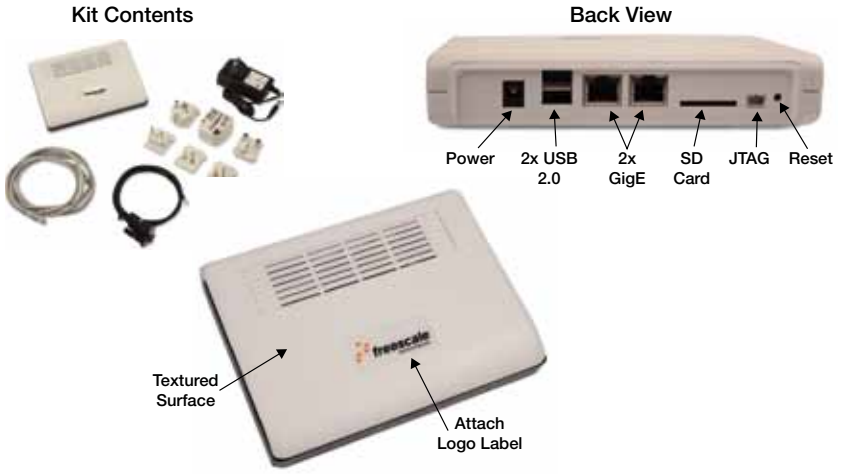
How Does NSG Work?

The Freescale MPC8308 NSG reference design with integrated ZigBee module (shown in Figure 2 earlier) enables connectivity with any ZigBee-enabled HAN device. This allows the HAN to be accessed and controlled over an M2M link between a smart hand-held device and NSG, using an intuitive GUI, as shown in Figure 4. The MPC8308-NSG supports HAN, wireless local area network (WLAN) and wide area network (WAN) connectivity, with an integrated MPC13226 ZigBee radio for HAN connectivity to smart meters as well as smart plugs and appliances, an integrated 802.11n 2x2 Wi-Fi® module that delivers over 300 Mbps of WLAN performance and support for broadband WAN connectivity via either cable, DSL or LTE/3G. In addition, NSG also supports the latest 2x2 802.11n Wi-Fi radio modules via its miniPCI connector, as well as dual Gigabit Ethernet ports, to enable true broadband connectivity. For wireless Internet connectivity, a 3G or 4G USB module can be attached via either of the two high-speed USB 2.0 ports that are provided on the NSG.

MPC8308-NSG Reference Design

The MPC8308-NSG reference design kit shown in Figure 5 includes a complete suite of OpenWRT software that requires no license fees and supports the following applications: GUI that enables Web-based access and management of connected devices and applications, networked video recorder (NVR) for home surveillance, HD video streaming and ZigBee HAN profiles for Smart Energy 1.0 and Home Automation 1.0. Freescale's NSG reference design features a compact, 4" x 5" four-layer board, and includes a cost-effective enclosure with dual antennas and power supply.

Figure 5: MPC8308-NSG Reference Design Kit



Key Features of Freescale's NSG Solution

- Seamless wireless connectivity (TCP/IP, 802.11n, ZigBee)
  - Smart metering via ZigBee sensors (via SE 1.0 or MBus)
  - Remote management and control of smart appliances (via ZigBee HA1.0)
  - M2M "anytime/anywhere" access and management, via smart handheld or Web-enabled devices
- Simple Web-GUI: Easy-to-use with any Web-enabled device
  - Meter reading, energy consumption and history
  - Alert notifications of tariff changes by utilities in real time
  - Demand response: Manage energy usage (HVAC, lighting, car charging, etc.)
  - Home automation and security
- Integration of four essential software stacks
  - TCP/IP: Broadband WAN/LAN connectivity
  - ZigBee Home Automation 1.0 Profile
  - ZigBee Smart Energy 1.0 Profile
  - Web-based GUI (Java) for ease of use

Key Advantages of Freescale's NSG Solution

- Cost-optimized bill of materials
- Enables "anytime/anywhere" access and control over an M2M link from any smart hand-held device via its graphical user interface (GUI)
- Provides a superb price/performance blend and the horsepower to run a variety of applications simultaneously
- Supports a rich mix of networking capabilities such as voice-over-Internet Protocol (VoIP), HD video streaming, and home security and surveillance in addition to energy management and control and home automation capabilities by leveraging Freescale's networking expertise
- CE and FCC Class A certified, RoHS compliant, ready for mass production
- Complete OpenWRT software suite

Conclusion

Bridging the smart grid with the HAN, Freescale's networked smart gateway solution delivers new possibilities in home energy monitoring, while allowing utility companies to tailor specific energy packages. The multi-application versatility and cost effectiveness of Freescale's networked smart gateway makes it an ideal solution for adding home energy management and control capabilities to a standard broadband gateway platform.

How to Reach Us:

Home Page:
freescale.com

Power Architecture Portfolio Information:
freescale.com/power

e-mail:
support@freescale.com

USA/Europe or Locations Not Listed:
Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
1-800-521-6274
480-768-2130
support@freescale.com

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064, Japan
0120 191014
+81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate,
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

For Literature Requests Only:
Freescale Semiconductor
Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447
303-675-2140
Fax: 303-675 2150
LDCForFreescaleSemiconductor@hibbertgroup.com

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright license granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. “Typical” parameters which may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including “Typicals” must be validated for each customer application by customer’s technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

freescale™

For more information, visit freescale.com/power

Freescale, the Freescale logo and QorIQ are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off. The Power Architecture and Power.org word marks and the Power and Power.org logos and related marks are trademarks and service marks licensed by Power.org. All other product or service names are the property of their respective owners.
© 2012 Freescale Semiconductor, Inc.

Document Number: PWRARBYNDBITSNSG REV 0

BUILT ON Power™