UH-HNEI Smart Grid Inverter Project

System Architecture

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Revisions

Version	Date	Change
1.0	8 August 2012	Final customer draft

Contents

1. Introduction

1.1. Overview

The Systems Architect Diagram shows a progression from simple to more complex reference architectures for usage in the development and testing of smart grid inverter communication specifications. Implementation of these specifications is for integration of high-penetration residential photovoltaic (PV) systems into pre-existing electrical distribution networks.

1.2. Glossary - Acronyms

Acronym	Definition
802.15.4	IEEE Standard for Low Rate WPAN
CIQ	Consumer IQ
AGF	Advance Grid Functionality
DER	Distributed Energy Resources
ESI	Energy Services Interface
HAN	Home Area Network (ZigBee IP + SEP 2.0)
HTTP/REST	Hypertext Transmission Protocol/Representational State Transfer
IP	Internet Protocol
NAN	Neighborhood Area Network (900 MHz RF Mesh)
NIC	Network Interface Controller
PV	Photovoltaic
RF	Radio Frequency
RS422	Recommended Standard 422 (Serial Interface Standard)
SEP 2.0	Smart Energy Profile 2.0
SoW	Statement of Work
SSN	Silver Spring Networks
TCP/IP	Transmission Control Protocol/Internet Protocol
UH-HNEI	University of Hawai’i – Hawai’I Natural Energy Institute
VM	Virtual Machine
WAN	Wide Area Network
WPAN	Wireless Personal Area Network

2. Smart Grid Inverter (SGI) System Architecture

2.1. Smart Grid Inverter (SGI) System Architecture Overview

A representation of the UH-HNEI Smart Grid Inverter System Architecture for high-penetration PV applications solution is presented in this section. The architectural development process is a phased approach progression in virtual, integrated and embedded environments. This approach improves hardware design and software debugging, allowing acceleration of the deployment of the embedded system.

This architecture framework includes inter-operability, modular components and key attributes including scalability and reliability.

The System Architecture Diagram shows the reference architectures among Head End, Energy Services Interface (ESI) and the Inverter in the system being modeled. The System Architecture Diagram is illustrated in Figure 1 and Figure 2. These diagrams may evolve throughout the development process in Phase 2 (Integrated Environment) and Phase 3 (Embedded Environment). All updates to be included in the deliverables associated with Silver Spring Networks Statement of Work (SSN SOW) Tasks 1.2a and 1.3a.

2.1.1. Head End

The Head End is the originating point in a communications system; in this case it is the utility. The Silver Spring Networks Customer IQ (SSN CIQ) web portal is used by the utility. The SSN CIQ is comprised of Distributed Energy Resource (DER) programs and controls that are sent to the ESI via a wide area network (WAN) and network area network (NAN).

2.1.2. ESI (Energy Services Interface)

The ESI is comprised of a Silver Spring Network Interface Controller (SSN NIC) programmed with firmware running the Zigbee IP and Smart Energy Profile 2.0 (SEP 2.0). The ESI communicates DER control functions to the Inverter.

2.1.3. Inverter

The Inverter is a device that converts variable direct current from a PV array into a utility frequency alternating current. This device is to be fitted with an Embedded Linux Board running the Zigbee IP and SEP 2.0, providing monitoring and control of the DER.

2.2. Phase 1: SGI Virtual Environment

Phase 1 was comprised of a virtual, proof-of-concept net metering schema. [Not shown]

2.3. Phase 2: SGI Integrated Environment

The Integrated Environment is comprised of the Head End, ESI and Inverter.

The Head End, the electric power company, uses the SSN CIQ web portal back office software to communicate via a wide area network (WAN) running the Hypertext Transmission Protocol/Representational State Transfer (HTTP/REST) protocol to the ESI. The ESI enables secure interactions between the WAN using HTTP/REST, and to the Inverter via an RS422 interconnection.

The ESI is comprised of a Linux Router running the SSN NIC firmware on an Embedded Linux Board running SEP 2.0 End Device DER Metering program. The Linux Router communicates by Ethernet via HTTP/REST with the WAN. The Embedded Linux Board communicates SEP 2.0 End Device Distributed Energy Resource (DER) Metering control functions to the Inverter via an Inverter Interface Library using the interconnection standard RS422.

A representation of the Integrated Environment, which includes special production hardware that has been successfully implemented on a virtual machine (VM), follows:

NB: The RS422 interconnection standard is being updated with the RS485 standard. The following diagram represents the present state of the system, and may evolve over the course of SSN SoW Task 1.2.

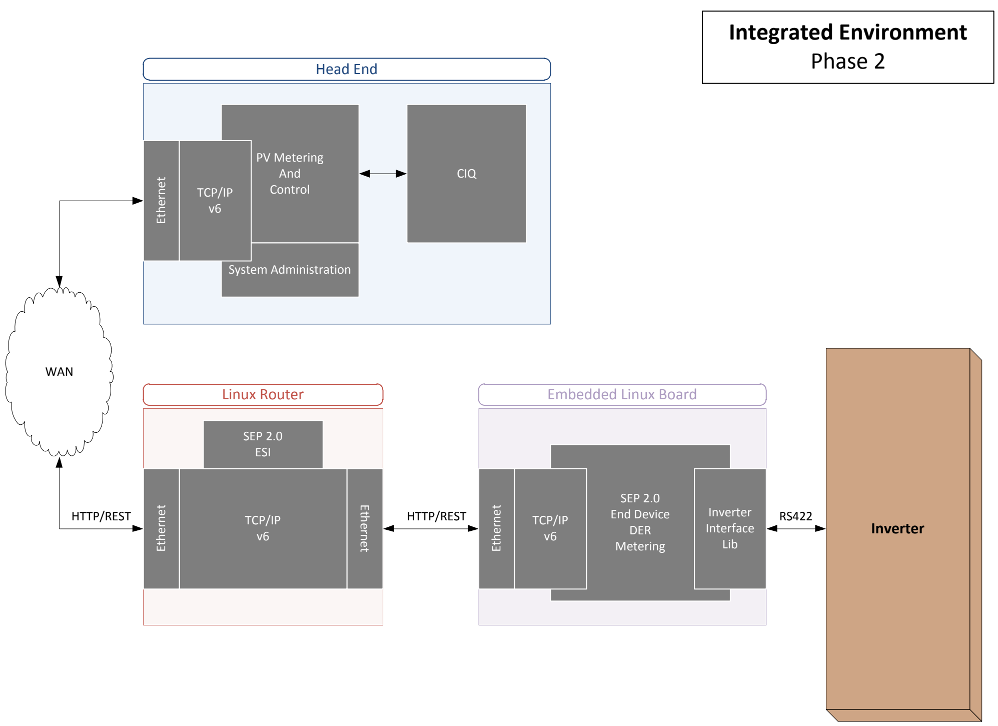

Figure 1. Integrated Environment - Inverter Deployment to the Integrated Environment [SSN SoW Task 1.2]

2.4. Phase 3: SGI Embedded Environment

The Embedded Environment is comprised of the Head End, ESI and Inverter.

The Head End, the electric power company, uses the SSN CIQ web portal back office software to communicate via Ethernet to a wide area network (WAN). The WAN runs the Hypertext Transmission Protocol/Representational State Transfer (HTTP/REST) protocol via an Access Point to a neighborhood area network (NAN). The ESI enables secure interactions between a neighborhood area network (NAN) and home area network (HAN), both running the HTTP/REST protocol.

The ESI is comprised of SSN NIC firmware running the SEP 2.0 ESI program. The SSN NIC communicates via a 900 MHz mesh to the NAN, and via the interconnection IEEE Standard 802.15.4 with the 2.4 GHz HAN.

The Inverter fitted with an Embedded Linux Board communicates SEP 2.0 End Device Distributed Energy Resource (DER) Metering control functions to the ESI via interconnection IEEE Standard 802.15.4 to the HAN.

A representation of the Embedded Environment for deployment in the field, which includes special production hardware, follows:

NB: The following diagram represents the present state of the system, and may evolve over the course of SSN SoW Task 1.3.

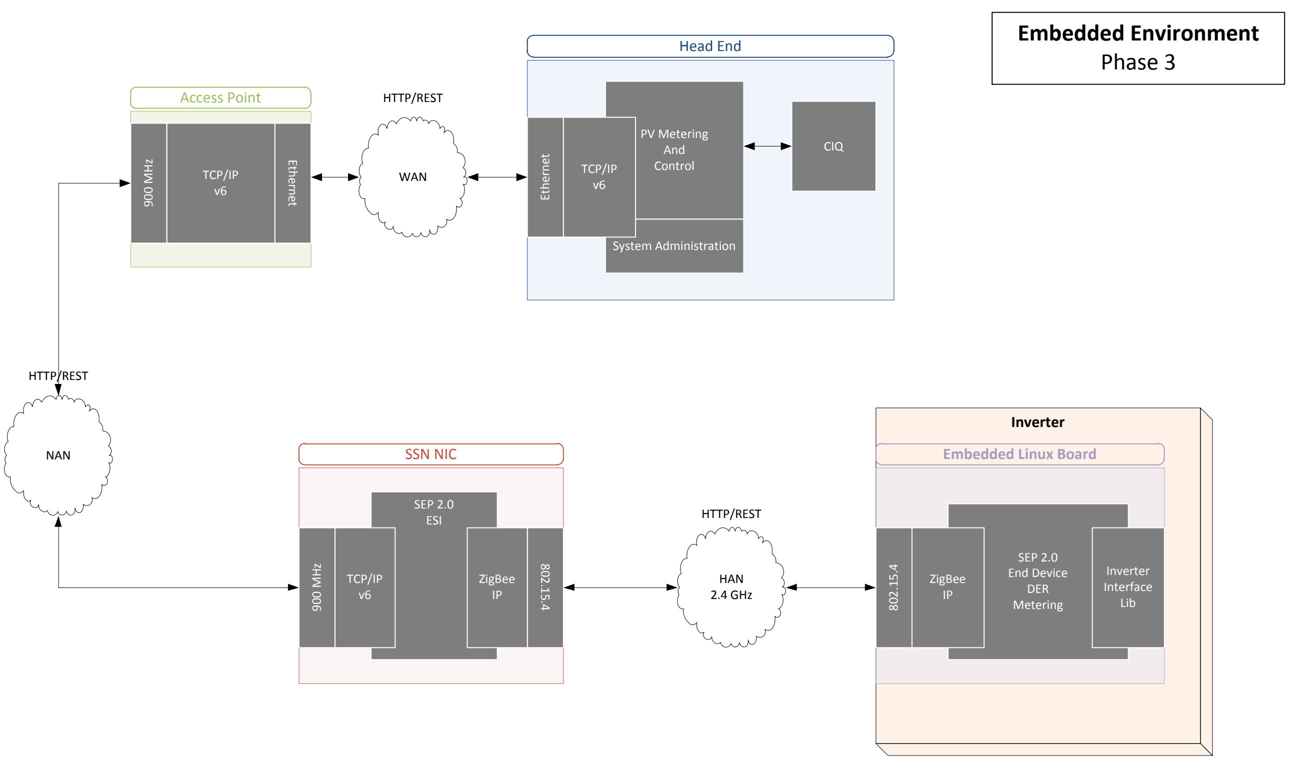

Figure 2. Embedded Environment - Inverter Deployment to the Embedded Environment [SSN SoW Task 1.3]