WHITE PAPER

Punya Prakash,
Business Manager,
Sitara™ processors
Texas Instruments

Data concentrators: The core of energy and data management

Introduction

Nearly 36 million smart meters were installed across the United States as of August 2012. In the European Union, smart meters continue to be deployed rapidly to meet the mandate that this technology reach 80 percent of households by 2020[1]. The technical and economic challenge of every installed meter directly communicating with utility servers makes the solution non-practical. With a large install base, it is essential to establish an automated metering infrastructure (AMI). With automated meter reading (AMR) measurement, the communication of meter data to the central billing station will be seamless. In addition to collecting energy usage information for billing, utility providers can leverage AMI to trouble-shoot and analyze any fault in the metering network.

Data concentrators are a critical node in the AMI; these aggregators are connected to several utility meters and a central utility server. This facilitates the communication of data between the meters and the energy service provider. Data concentrators, at several points in the infrastructure, securely aggregate data from a manageable number of meters and relay the information to the centralized utility servers.

In this white paper, we discuss the smart grid AMI, focusing on the data concentrators. We will outline the role Texas Instruments (TI) Sitara™ processors play in facilitating intelligent automation of the AMI unit as demonstrated through a comprehensive system reference solution. The scalable TI processor portfolio offers an opportunity to build a platform solution that can be tailored based on the data concentrator requirements.

Data concentrator

Advancement in smart grid technology has transformed the energy segment. With improved infrastructure, a bi-directional flow of energy and data information can be achieved. The key to optimizing this complex network of intelligent systems is automation of the core components.

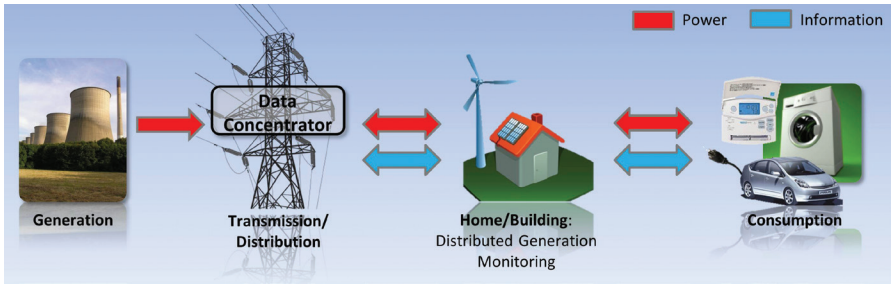


Figure 1: Smart grid infrastructure demonstrating two-way energy and data flow

The AMI is inclusive of intelligent meters that record electricity consumption at regular intervals, providing the data to the utility provider. The frequency of this data feedback ranges from an hourly feedback meter to real-time meters with a built-in two-way communication structure. These systems have the capability of recording and transmitting instantaneous information. The recorded data provides more information on the load of the various end points that are actively consuming energy.

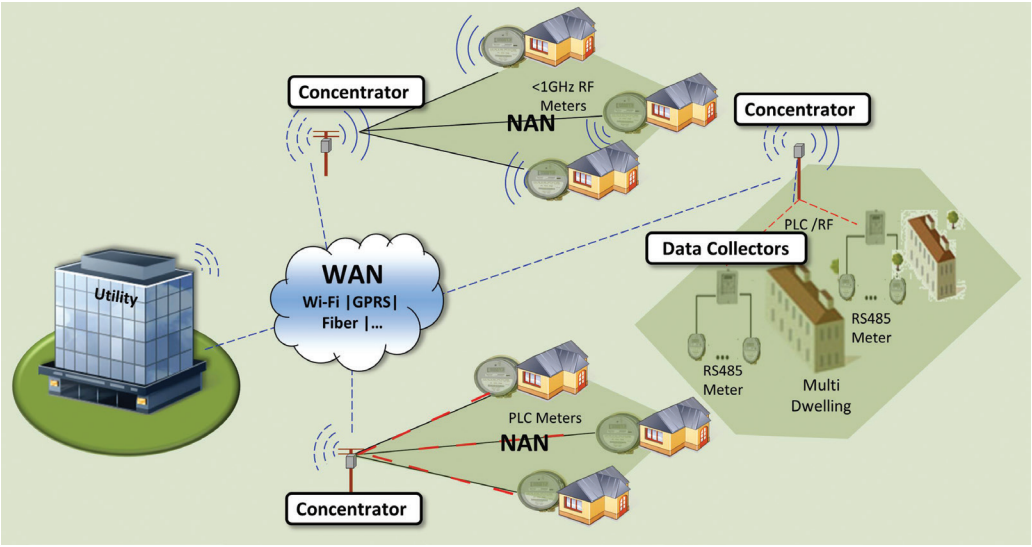


Figure 2: Typical data concentrator network

A data concentrator is the core of data and energy management in an AMI. It provides the technology to measure and collect energy usage data. The concentrator can also be programmed to analyze and communicate this information to the central utility database. Not only can the utility providers could use this information for billing services, but can improve customer relationships through enhanced consumer services such as real-time energy analysis and communication of usage information. Additional benefits of fault detection and initial diagnosis can also be achieved, further optimizing the operational cost. A data collector can act as an intermediate aggregator for high density, multi-dwelling buildings.

There are two types of networks connecting to data concentrators:

- **NAN:** Neighborhood Area Network
- **WAN:** Wide Area Network

Data concentrators communicate information through the grid through aggregation of information from various meters. Additionally, its benefits include:

- **Smart metering** – instant read, load profile, billing information and remote management
- **Inventory management** – give utilities better visibility into its assets
- **Optimization of network** – real-time topology display, performance management and benchmarking

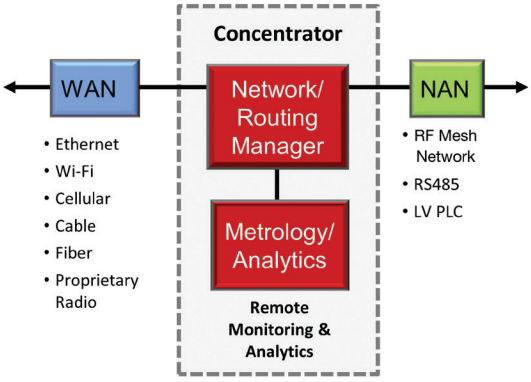


Figure 3: Data concentrator functional block diagram

There are multiple challenges in the AMI market today, specifically for data concentrator applications.

Multiple communication standards

The metering installations support various communication standards in different regions. In addition to the new protocols, older communication interfaces based on RS-485 should also be considered while designing a platform solution. The key for a scalable concentrator platform is to be fully functional with meters and back-end management systems from various vendors implementing compliant technology proving **multi-vendor interoperability**.

Software infrastructure

To deploy **multiple communication standards** on a single system, it is essential to have a robust software foundation. Ideally, with validated communication firmware, vendors can invest in developing applications to customize their system offering. Smart grid applications such as transformer detection and energy balancing can be developed by taking advantage of this advanced technology.

With smart meter rollouts, the abundance of energy usage information can be used by utility companies to boost customer experiences. This aggregation of information requires data- and energy-managed solutions. By improving the **data management and networking security**, utility companies can deploy applications though which consumers can have higher granularity into their energy consumption.

Field approval

Field tests and approval of this technology are significantly time consuming. Using **field-proven technology** will mitigate the risk significantly improving the time to market. These outdoor installations call for systems with high integration to be built for rugged environment.

TI system solution

TI's Sitara AM335x processor-based data concentrator evaluation module (EVM) addresses some of these challenges. With proven hardware and a robust software solution, these system solutions improve the time to market considerably.

Depending on the system requirements, TI offers a data concentrator EVM with various performance, cost and connectivity options. The Sitara AM335x processor-based TMDSDC3359 EVM aids higher network capability. TI's highly scalable AM335x processor enables expanded wired and wireless connectivity options through flexible peripherals. With frequency ranging from 300MHz to 1GHz, this pin-to-pin compatible processor provides the flexibility to also add more service nodes to the system.

The communication mode used in the system largely depends on the power infrastructure. The data concentrator unit can be based on wired or wireless communication. Power line communication (PLC) based wired communication is gaining market share, while serial or Ethernet-based systems continue to grow at a steady pace. Wireless systems are primarily based on Sub-1Ghz RF (IEEE 802.15.4g protocol) communication.

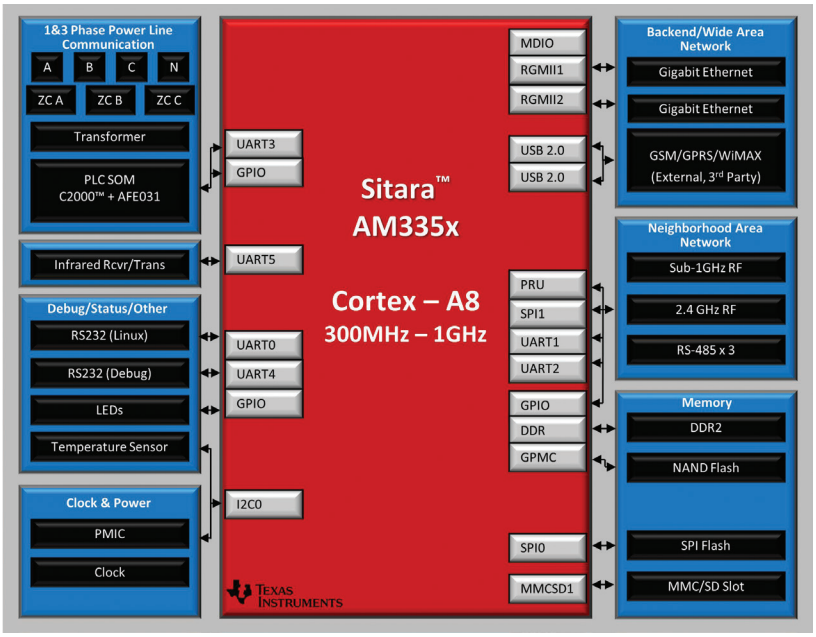
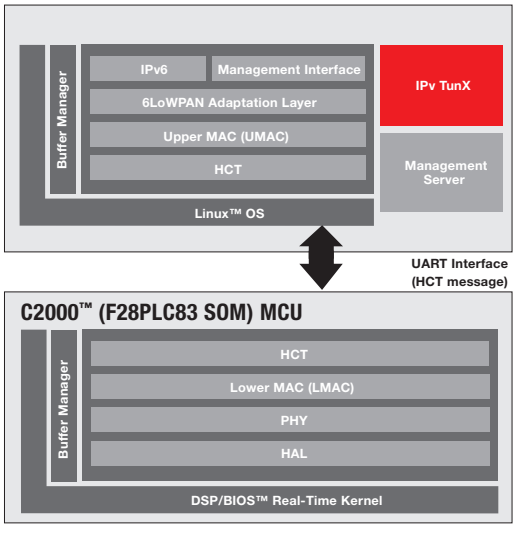


Figure 4: Example of a data concentrator using an AM335x processor

Data from the concentrator to the utility servers can be transferred via Ethernet, GSM, GPRS or other telecom networks. With support for DDR2/3 memory, integrated Gbit-Ethernet, CAN, MMC/SD, USB and up to eight UARTs, the TI Sitara processor supports various communication media, including RS-232, RS-485, Infrared and wireless modules.

With system-tested Linux™-based software solution, the TI system solution offers:

- Complete PHY and MAC layer software for power line communication (G3, PRIME, IEEE-1901.2)
- IPV4 / IPV6 / 6LowPAN networking protocols
- DLMS/COSEM applications from third-party Aricent



G3 Stack

- Sitara processor
  - ADP 6LoWPAN Bootstrapping
  - Mesh routing (LOAD)
  - Security EAP/PSK
  - Upper MAC
- C2000™ microcontroller
  - Lower MAC and Prime PHY

G3 DC Interfaces

- Management
- DLMS/COSEM IPv6 application

G3 Topology

- Maximum 2000 nodes

Figure 5: G3-PLC Base Node Stack from Texas Instruments

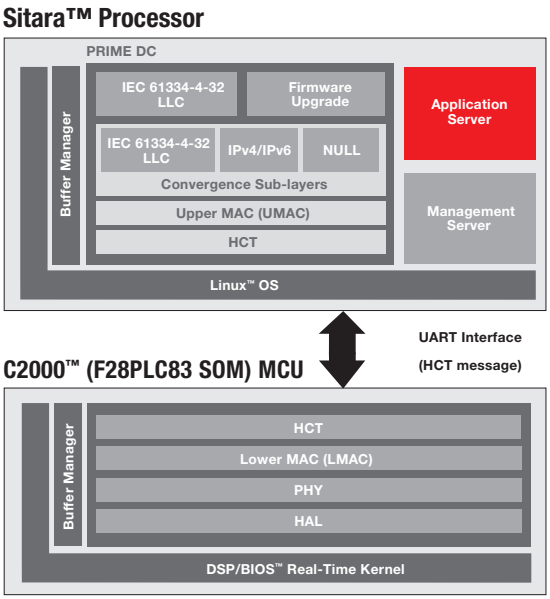


Figure 6: PRIME Base Node Stack from Texas Instruments

PRIME Stack

- Sitara processor
  - IEC-61334-4-32 LLC
  - IEC-61334-4-32 SSCS and NUL SSCS
  - Upper MAC
- C2000 microcontroller
  - Lower MAC and PRIME PHY

PRIME DC Interfaces

- Management
- Application

PRIME Topology

- 2000 nodes
- 32 switches
- 3600 connections (Unicast and Management)

Features and benefits of TI processors for data concentrators

- TI's Sitara AM335x processors provide the necessary performance to implement complex routing algorithms in the data concentrator. This enables the system to connect with more than 2,000 e-meters.
- The AM335x processors span a wide range of performance (300MHz to 1Ghz) with pin-to-pin compatibility
- Processor SDK enables quick development with out-of-the-box demos and benchmarks and enables seamless software reuse or migration across devices. TI provides Linux or RTOS distributions free of charge.
- Integrated communication interfaces include two Ethernet (MAC) ports, USB and up to eight UARTs for quick and easy connectivity to other systems on the smart grid.

Conclusion

A data concentrator is the core of the AMI system and improves the overall energy and data management of the smart grid system. These systems provide the means to collect energy-utilization information and relay it back to the central utility servers. Utility companies could use this data and provide higher granularity of energy usage to its end consumers, improving the overall customer experience. With these intelligent systems, the operational efficiency of the grid can also be improved through seamless billing information and grid network fault detection.

TI's Sitara Arm processors address several of the challenges associated with data concentrator design. The AM335x processor can enable a wide variety of connectivity standards and can support a wide range of end nodes with processors of varying performance. Additionally, Processor SDK provides resources to get started quickly and reuse IP in the future to help customers reduce their time to market.

For more information about TI's Sitara AM335x processors, please visit ***www.ti.com/am335x****.*

Resource

[1] Smart meter deployments continue to rise – U.S. Energy Information Administration: **http://www.eia.gov/todayinenergy/detail.cfm?id=8590**

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