SmartGrid Australia

Intelligent Networking Working Group

Study Topic 3:
SmartMeter to HAN Communications

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Study Topic 3: Definition

- What is the role of the Premise Energy Management System (PEMS) and how will it transform the way in which electricity usage is controlled and monitored within the home?
- Within the Home Area Network (HAN), what communications methods are applicable for interworking the Premise Energy Management System to end points and SmartMeters?

Out of Scope

- Delivery Models
  - e.g. Ownership of PEMS and related issues such as security, management and liability.
- Architecture Scenarios
  - While the PEMS deployment scenarios may vary from an Inception (integrated PEMS and SmartMeter) through to a Consumer Choice or Mature Systems (independent PEMS and SmartMeter) model, this study focuses only on the latter.
- Water and Gas Management
  - While not specifically addressed in this study; the PEMS can be extended to address water and gas management requirements.

Previous Global Work in the HAN

- GridWise Interoperability Context-Setting Framework
- OpenHAN – UtilityAMI 2008 – HAN System Requirements Specification
- SmartGrid Australia – Interoperability Workgroup
- HomeGrid Forum
- U-SNAP Alliance
- DLNA – Digital Living Network Alliance
- IPSO – IP for Smart Objects

Situation Analysis

Enabling Visibility and Control

- Need for granular dynamic demand control = cost savings for the Utility and Consumer
- Consumer has become more “Green” conscious and therefore is looking for real-time visibility of energy consumption
- Capability for real-time messages from Utility
- Emergence of Consumer generated “2-way” distributed micro generation energy resources
- Increase in Consumer demand for reliable energy as the number of household Electronic devices increases
- Proliferation of Home LAN and Internet access (67% penetration)* among Australian households

Source: *2008, www.budde.com

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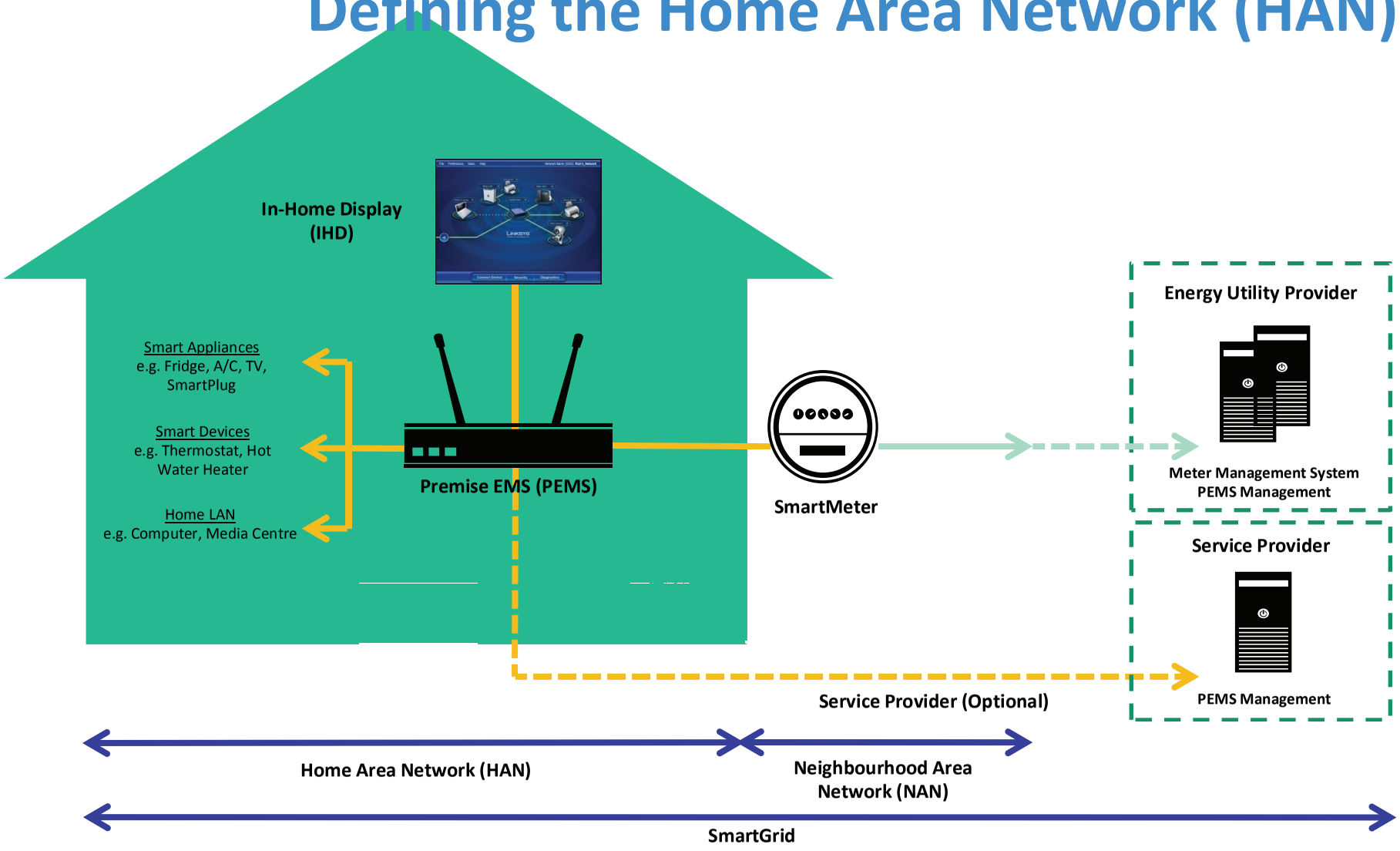
Defining the Home Area Network (HAN)



Premise Energy Management System (PEMS)

Definition

- PEMS enables home energy control and monitoring providing benefits to both consumers and utilities
- PEMS intelligently monitors and adjusts energy usage by interfacing to SmartMeters, SmartDevices, appliances and Smart Plugs. It provides effective energy and peak load management
- The platform for this communication is the Home Area Network (HAN)
- HAN should be IP based so that seamless end-to-end and cost effective connectivity can be achieved
- SmartMeter is intended to perform basic functions which allow it to have a long lifecycle (~20-30 years) without any software or hardware changes
- PEMS provides a level of intelligence implemented in software that can reside on an independent hardware platform and be decoupled from the SmartMeter. It can be upgraded on a more frequent basis and easily incorporate new functions and protocols. It can also serve as a central hub linking all aspects of the HAN such as entertainment, energy and security

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PEMS: Consumer Benefits

Energy Monitoring

- Real Time Energy Usage
- Historical Energy Usage
- Individual Appliance Usage

Energy Efficiency Portal

- Appliance Energy Efficiency
- Energy Alerts
- Energy Saving Tips
- Community Energy Portal

Electricity & HVAC Control

- Monitor Environment Conditions (such as temperature)
- Control HVAC (Heating, Ventilation and Air Conditioning) Systems
- Control Smart Appliances and Smart Plugs

Digital Energy Passport

- Home Energy Consumption overview reports

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PEMS: Utility Benefits

Demand Management

- Peak load management data available to Energy Suppliers
- On Demand Response requests for appliance control
- Demand Response integration with Household profiles
- Demand Response operation validation

Management of Micro Generation

- Measurement of distributed micro generation
- Integration of Demand Response into Distributed Micro Generation
- Distributed Micro Generation optimization based on pricing and household conditions
- Revenue forecasting

Management of Electric Vehicles

- Optimise Plug in Hybrid Electric Vehicle (PHEV) Charging
- Control of storage feed to the grid
- Optimise PHEV feed revenue
- PHEV Consumption Statistics

PEMS: Other Value-Add Benefits

Value-Add Services

- **Home Automation and Control**
  - Appliance control
- **Appliance Services**
  - Electrical Appliances
  - Heating servicing
- **Physical Security**
  - Physical Access control
  - Smoke/Fire/Temperature/CO Alarms
  - Water leak monitoring
  - IP CCTV
- **Health (Independent Living)**
  - Senior Citizen Alarms
  - Health Monitoring

Value-Add Services

- **Holiday Services**
  - Security
  - Holiday energy saving mode
- **Multimedia**
  - Entertainment control
  - Content Vaulting
- **Voice and Video Communications**
  - Internet Telephony
  - Video Conferencing
- **Advertising**
  - Energy Related
  - Home Advise

PEMS: Considerations

- Unit Cost?
  - Affordability for Utility, Service Provider and/or Consumer.
- Security?
  - Communication with HAN end points and SmartMeters must be encrypted and authenticated to prevent malicious activity, especially when used with borderless protocols.
- Management?
  - Equipment must be easy to provision. Software changes, configuration updates, data collection must be handled remotely.
- Longevity?
  - Lifespan must be close to existing household appliance lifecycle. 8+ years.
- Interoperability?
  - In order to ensure rapid adoption and ease of use for consumer, interoperability with HAN end points and SmartMeters must be ensured.

PEMS: Management

- Key Functions of the PEMS Management Platform:
  - PEMS Registration and Status Monitoring
  - Collection point for PEMS data
  - Remote PEMS provisioning, management, configuration, software update
  - Backup and Restoration of PEMS data
  - PEMS Firmware upgrades
  - Demand Response head-end function
  - Peak Load Management functions
  - Interface with Utility's billing and other business applications

- Examples of PEMS Management Functions:
  - Calculating energy savings that could be achieved if peak load management measures were enforced
  - Predicting how many households would participate in a peak load management event based on real-time information

PEMS: Security

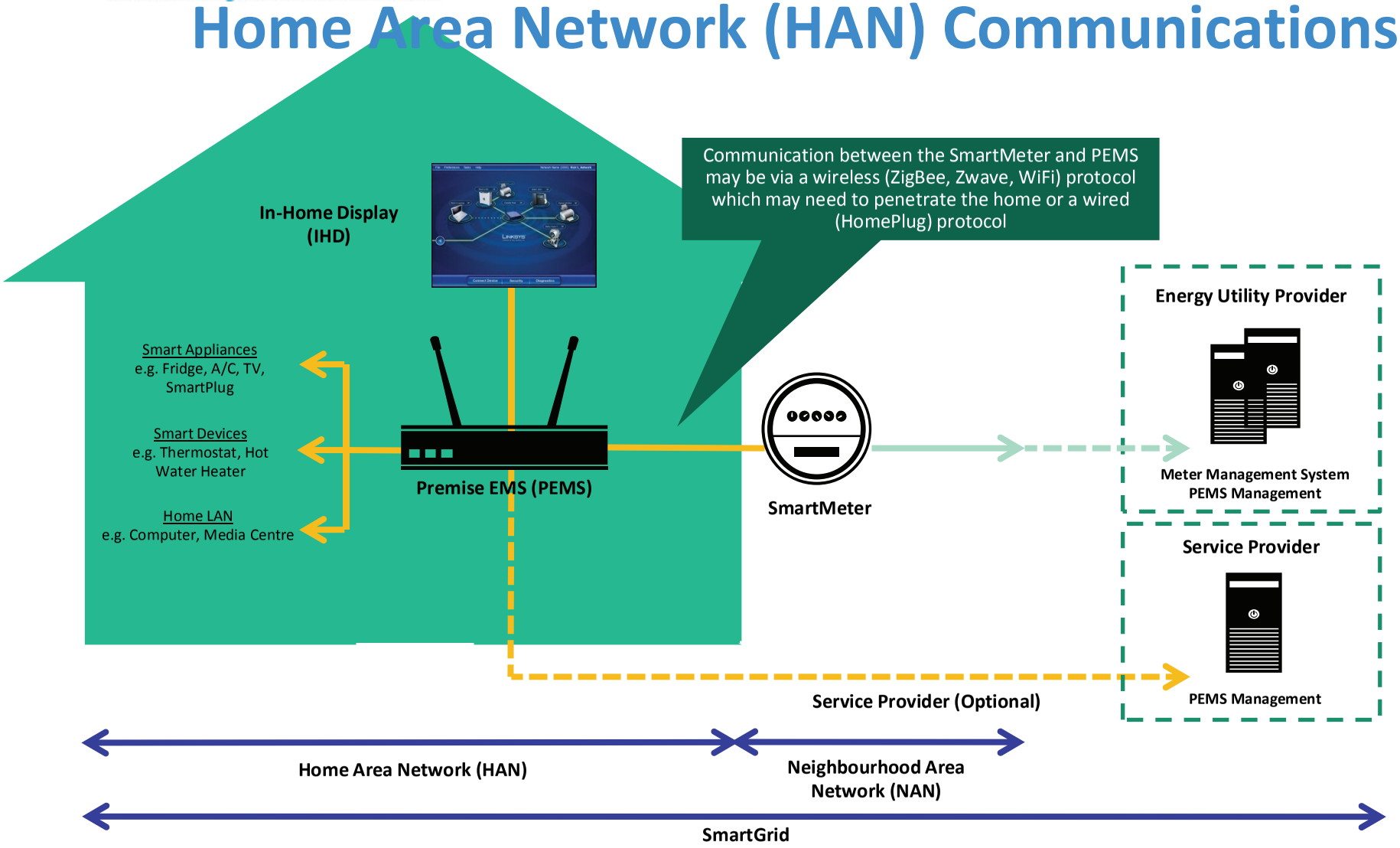
- Security within the HAN is important to maintain consumer and utility data integrity, privacy and availability.
  - It is multifaceted and may cover several aspects including authentication and encryption where any communication between different end points occur.

- Examples of existing network security solutions that may be applied within the HAN include:
  - SSL (Secure Socket Layer) or TLS (Transport Layer Security) connection for secure access to the configuration. SSL/TLS are cryptographic protocols that provide security and data integrity for communications over IP networks.
  - Basic firewall functionality to enable validation of legitimate traffic and DDoS (Distributed Denial of Service) prevention mechanisms.
  - Secure connection to Energy Utility Provider, SmartMeters and to other components on the HAN.
  - Remote user access and role based access control.
  - User Authentication allowing access to the PEMS device and In-Home Display (IHD).

PEMS: Deployment Models

- Utility Managed
  - PEMS is fully owned and managed by Utility. Utility provides incentive to the consumer to use PEMS and also owns backend infrastructure for management and provisioning.
- Service Provider Managed
  - PEMS is managed and provisioned by Service Provider. Utility may consider risk of allowing a third party managed PEMS to participate in Demand Response.
- Consumer Owned and Managed
  - All configuration done by the consumer. Energy optimisation possible through the pricing signals sent by Utility. Consumer decides on whether to participate or not.

Home Area Network (HAN) Communications



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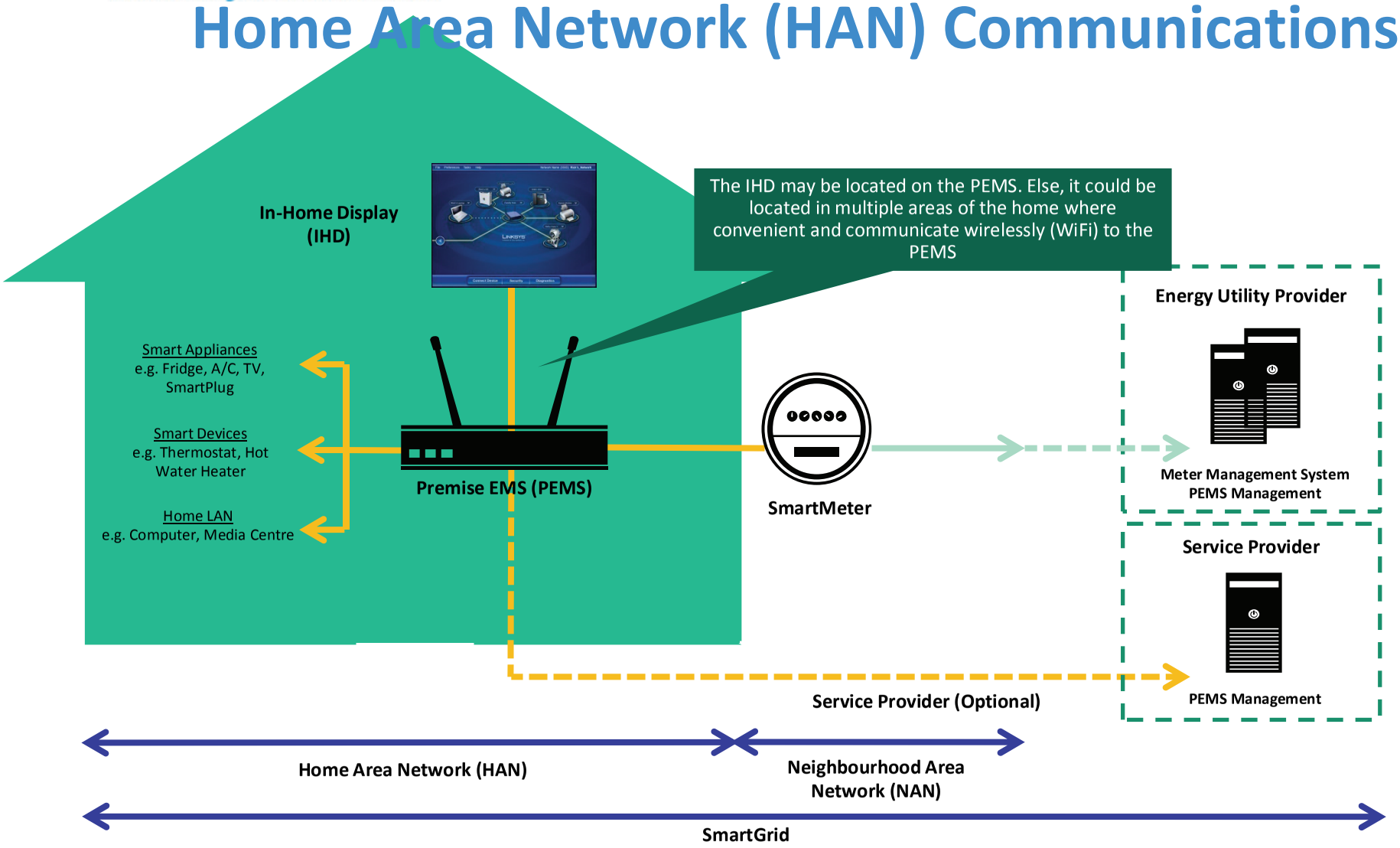

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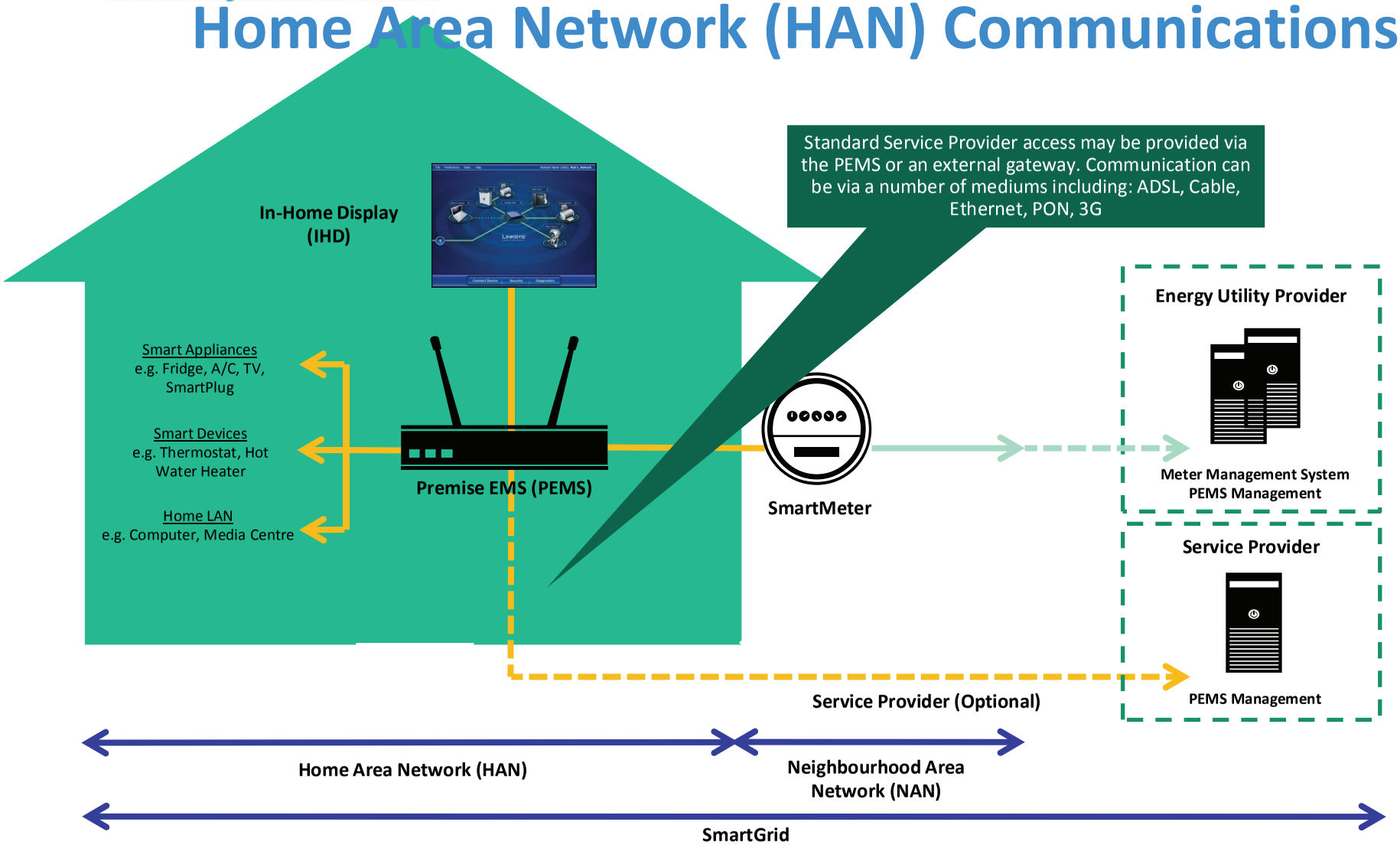

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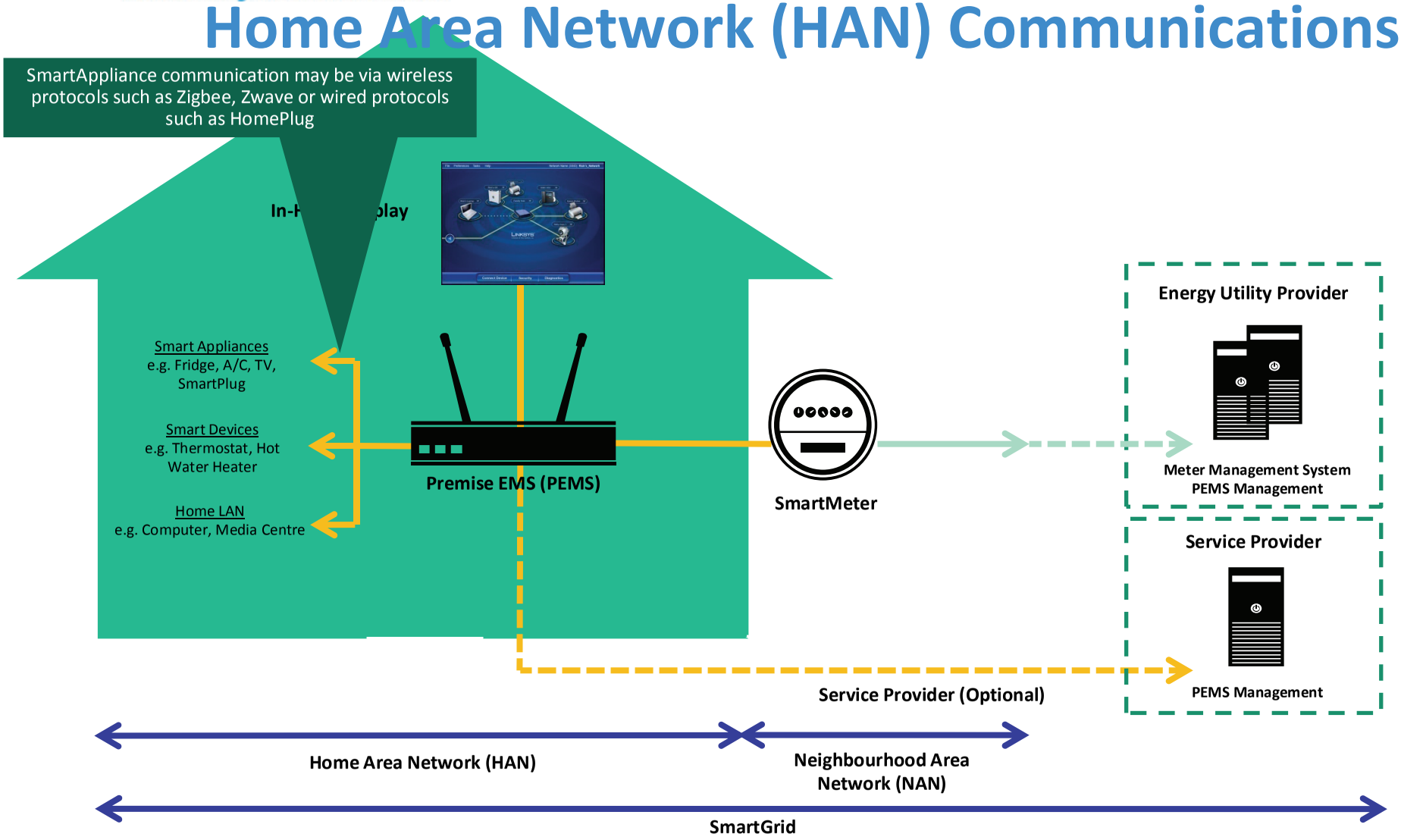

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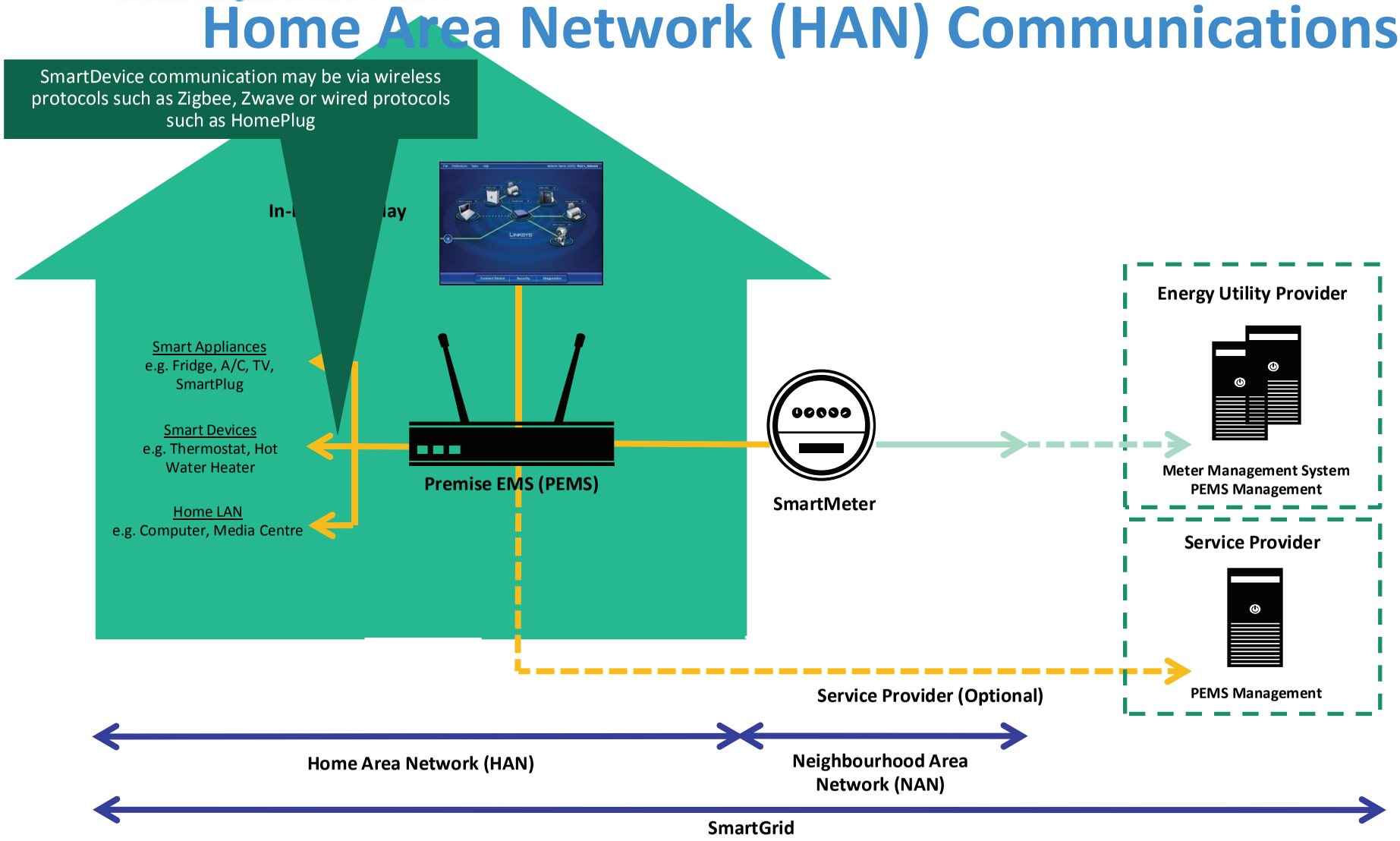

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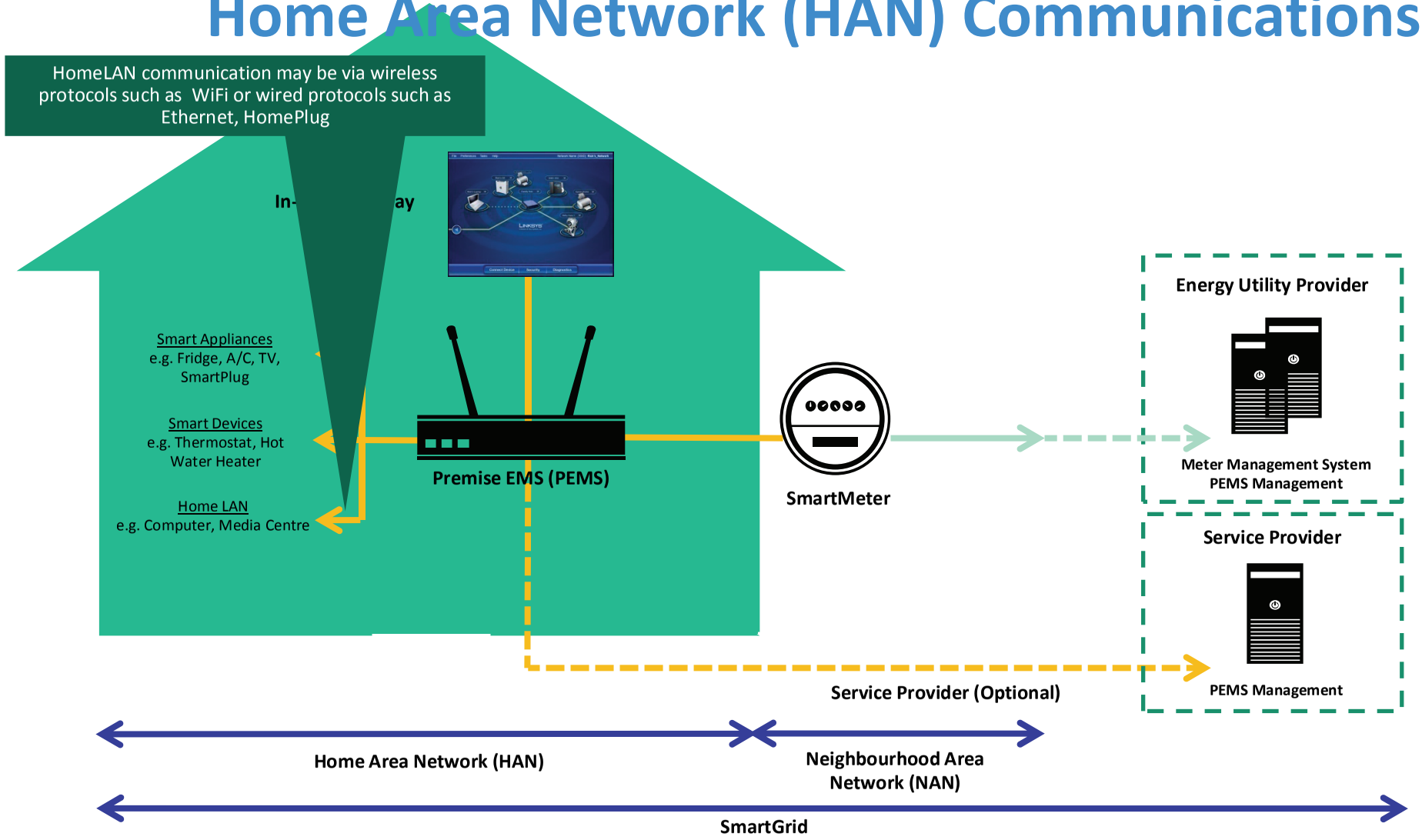

Home Area Network Protocols: Zigbee

- Wireless mesh proprietary networking solution (from Layer 3 to the application layer) built on the IEEE 802.15.4 media standard.
- The low power network must exclusively be made of devices interconnected by IEEE 802.15.4 links.
- The raw, over-the-air data rates are:
  - 250 kbps per channel in the unlicensed 2.4 GHz band (Worldwide)
  - 40 kbps per channel in the unlicensed 915 MHz band (Australia and US)
  - 20 kbps in the unlicensed 868 MHz band (Europe)
- Reach is 10-75 metres point to point, typically 30 metres indoors; unlimited with mesh networking. In a mesh network, nodes are interconnected with other nodes so that at least two pathways connect each node. Connections between nodes are dynamically updated and optimised . Mesh networks are decentralised in nature; each node is self-routing and able to connect to other nodes as needed. The characteristics of mesh topology and ad-hoc routing provide greater stability in changing conditions or failure at single nodes.
- Low cost allows wide deployment in wireless control and monitoring applications; the low power-usage allows longer life with smaller batteries (up to 10 years) and the mesh networking provides high reliability and broader range.
- Provides secure connections between devices through 128-bit AES encryption.
- Currently no IP support. Interoperability remains an issue until Smart Energy Profile 2.0 is released, when Zigbee will support IP.

Home Area Network Protocols: Z-Wave

- Z-Wave is a proprietary wireless communications standard designed specifically to remote control applications in residential and light commercial environments.
- Due to an impressive eco-system community Z-Wave is widely spread although it is not open and is available only to Zensys customers. Zensys is now a division of Sigma Designs.
- The Z-Wave Radio uses the unlicensed 900 MHz ISM (Industry, Scientific and Medical) band. 900MHz is unlicensed radio frequency band used in Australia, Israel and North America, while 2.4Ghz is unlicensed band used world wide including Australia. Generally, 900MHz solutions provide significantly longer range and lower power than those operating in 2.4GHz.
- Reach is approx 30 metres point to point open-air, reduced indoor; unlimited with mesh networking and bandwidth 40kbps.
- Optimized for low-overhead commands such as on-off (as in a light switch or an appliance) and raise-lower (as in a thermostat or volume control), with the ability to include device metadata in the communications.
- The freedom from household interference (WiFi, Microwave, Cordless Phone) allows for a standardized low-bandwidth control medium that can be reliable alongside common wireless devices.
- IP support announced in May 2009 through IP-Wave product. Sigma Designs announced that “IP-Wave will remain backwards compatible to existing Z-Wave products while adding compliant IP services to Z-Wave nodes.”

Home Area Network Protocols: HomePlug

- HomePlug is a power line communication technology. It uses the existing home electricity wiring to communicate.
- To create a network, a user connects two or more adapters to the power outlets in the home. The user can then connect devices to the network via the adapter.
- Alternatively, devices may already have HomePlug adapters built in, and therefore it is just a manner of connecting the devices to the home power outlet to enable network connectivity.
- Several HomePlug specifications exist. HomePlug 1.0 supports theoretical speeds up 14 Mbps while HomePlug AV supports theoretical speeds up to 200 Mbps. A standard also exists currently in draft: IEEE P1901.
- Security with HomePlug AV is provided via 128-bit AES Encryption.
- HomePlug Command & Control (HPCC) is an alternative to the AV version and is designed for lower speed, very low-cost applications.
- Supports a number of protocols including IP.
- Setup and configuration may take a level of skill.

Home Area Network Protocols: Ethernet

- Ethernet is a very common communication technology standard primarily used within the LAN but can also be used on the WAN.
- Devices can connect to the Ethernet network in a variety of ways including copper “twisted-pair” cabling or fibre optics.
- Predominantly, copper cabling is used in Home LAN’s. With the copper cabling connecting to a hub or switch in a star topology. This hub or switch may also serve as a gateway providing ADSL/Cable/3G access to an ISP.
- A variety of speeds can be achieved including: 10 Mbps, 100 Mbps, 1000 Mbps and 10000 Mbps. 100 Mbps is the most common speed found in the Home LAN although 1000 Mbps is making an appearance as high bandwidth media such as Video and Network Attached Storage (NAS) becomes more prevalent.
- The majority of network attached devices today come with Ethernet interfaces, including personal computer, laptops, servers, printers, AV equipment, media console, game consoles.
- Being standards based setup and configuration is very easy.
- Ethernet may not be appropriate for connecting all devices in the HAN (especially appliances) due to the high cost and power requirements plus the need for separate cabling back to a central point.

Home Area Network Protocols: WiFi

- WiFi is a popular wireless technology used in home networks, mobile phones, video games and other electronic devices.
- Based on mature IEEE 802.11 standards:
  - 802.11n (~ 300 Mbps); 802.11b (11 Mbps); 802.11g (54 Mbps); 802.11a (54 Mbps)
- Support is wide spread with nearly every modern personal computer, laptop, game console and peripheral device provides a means to wirelessly access the network via WiFi.
- WiFi is generally upper layer protocol agnostic with IP being the most predominate protocol.
- Setup and configuration may take some level of skill.

Home Area Network Protocols: Internet Protocol (IP)

- IP is a protocol used for communicating data within a packet switched internetwork. It is responsible for delivering data from source to destination based on a IP address.
- IP is the foundation on which the Internet is built and communication is achieved.
- IP is a single layer within a multi-layer suite known as the TCP/IP stack. Due to this abstraction, IP can be used across a number of different heterogeneous network technologies, including: Ethernet, WiFi, HomePlug without translation.
- The design of IP infuses the view that the underlying network is inherently unreliable and therefore is a “best effort” delivery mechanism. It is the responsibility of the upper layer protocols to provide reliability.
- Due to the ease of interoperability, ubiquitous nature, wide spread adoption and work being performed to create a lightweight interface (6LoWPAN), IP is being seen as essential to the success of HAN and SmartGrid development.

Home Area Network Protocols: IPv6

- IPv6 is the next-generation IP communication protocol for internetworks and the Internet. It is primarily aimed at evolving the current IPv4 protocol which is predicted to be exhausted of address space in 2011.
- IP addresses enable devices on an IP network to communicate with each other.
- As an indication of the scale of change, IPv6 supports 128-bit addresses (3.4×10^8) as opposed to IPv4 which supports 32-bit addresses.
- As the significance of devices communicating within the HAN increases, so does the requirement for usable IP addresses.
- While methods exist today to translate from IPv6 to IPv4 and vice-versa, the degree of complexity, overhead and cost is significant. Therefore the requirement for native IPv6 communication in devices with a long lifecycle is imperative.
- 6LoWPAN is a standard from the IETF published in 2007. It optimises IPv6 for use with low-power, low-bandwidth communication technologies such as the IEEE 802.15.4 radio. 6LoWPAN works by compressing 60 bytes of headers down to just 7 bytes.
- The target for IP networking for low-power radio communication are the applications that need wireless internet connectivity at lower data rates for devices with very limited form factor.
- 6LoWPAN allows communication with devices across the Internet without having to go through Zigbee-to-IP translation.

Home Area Network Protocols: ITU G.hn

- Next generation HAN standard developed under ITU and promoted by HomeGrid Forum.
- It supports networking over power lines, phone lines and coaxial cables.
- Expected data rates up to 1Gbps.
- Provides secure connections between devices through 128-bit AES encryption. Authentication and key exchange is done following ITU-T Recommendation X.1035.
- G.hn natively supports popular protocols like Ethernet, IPv4 and IPv6 and as a result G.hn-based Energy Management networks can easily be integrated with IP-based SmartGrids.
- Availability of G.hn-compliant chips is expected during CY2010.
- Common criticism is that G.hn is incompatible with some of the established technologies in the market, including HomePlug AV.
- Key advantages are ability to connect to any room regardless of wiring type, consumer self-install, built-in diagnostic information and self management as well as multiple equipment suppliers.

Home Area Network Protocols: Summary

	Zigbee	Z-Wave	WiFi	HomePlug	Ethernet
Connectivity	Wireless	Wireless	Wireless	Wired	Wired
Max Speed per Channel	250 kbps (2.4 GHz) 40 kbps (915 MHz)	40 kbps	11 Mbps – 300 Mbps	14 Mbps – 200 Mbps	10 Mbps – 1000 Mbps
Reach	10 -75 m (30 m typical)	30 m open-air, reduced in-door	100m (Indoors)	300m	100m (Twisted-Pair Cable)
Is It IP Based?	Not today. SEP 2.0 will be IP based.	Not widely. First IP based chipsets recently announced	Yes. IPv6	Yes	Yes
Standards	- IEEE 802.15.4 - Proprietary (L3-L7)	Proprietary (Zensys)	IEEE 802.11	IEEE P1901 Specifications: HomePlug 1.0, HomePlug AV, HomePlug CC	IEEE 802.3
Adoption Rate	Widely adopted	Widely adopted	Extremely High	Medium	Extremely High
What Unique Value Does It Bring?	Low cost, low power-usage, longer battery life (up to 10 years)	No interference from household devices in 2.4 GHz range	Widely adopted high speed wireless communication with a mature set of standards. Wi-Fi interface is very common found in most devices including PC's, AV Equipment , Games Consoles and Laptops.	High speed using existing home electrical cabling. Enables appliances to communicate through the standard electrical outlet reducing the amount of configuration effort for the consumer.	Widely adopted, high speed wired communication. Common interface found in a number of household equipment, including, PC's, AV equipment, games consoles.

Potential Areas for Further Work

- Develop an interoperability framework (key parameters and standardisation options) to enable the Premise Energy Management Systems (PEMS) to function across all Utilities in the Australian environment and to support a wide range of deployment models.
  (This activity would require participation from the Energy Retail sector)

- Further review of PEMS requirements to support specific delivery model scenarios.

- Investigation of appliance level interoperability to support PEMS.

Conclusions

- HAN can be seen as an extension of SmartGrid
- PEMS provides value to the Consumer, Utility and Service Provider by enabling granular real-time demand control, visibility and access
- PEMS provides a means of converging data and electricity networks acting as a central hub and linking communications between SmartAppliances, SmartDevices and the Home LAN
- PEMS may provide additional “value-add” capabilities for Service Providers and Utility Retailers through services such as advertising, physical security, multimedia entertainment control
- The choice of protocols used within the HAN are important to the success of the PEMS and must be driven by industry wide collaboration and adoption. SGA is a perfect vehicle to drive these discussions and standards
- IP is ubiquitous and enables rapid adoption. Scalability of IP is achieved through support of IPv6
- PEMS may play a part as a “translation” gateway of different protocols within the HAN enabling interoperability

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