**IEEE P802.24**

**Vertical Applications Technical Advisory Group**

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| Project | IEEE P802.24 Vertical Applications Technical Advisory Group |
| Title | **Proposed Texts and Figures of Clause 4.1.4 “Integrating EV charging in an EMAP network” in the Draft White Paper (Doc. 24-23-0007-00-0000)** |
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| Re: |  |
| Abstract | This contribution proposes Texts and Figures of Clause 4.1.4 “Integrating EV charging in an EMAP network” in the Draft White Paper (Doc. 24-23-0007-00-0000) |
| Purpose | To be added and merged in the draft White Paper (Doc. 24-23-0007-00-0000) |
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### Integrating EV charging in an EMAP network

### Energy management for Smart home integrated with EV charging

Smart Home can implement a system that attempts to coordinate and control when the house needs smart services for heating, air conditioning, distributed energy resources (DERs) and Electric vehicles (EVs) to increase energy efficiency (e.g., power balance, power-sharing, energy management, and optimizing) [6]. DER energy sources (such as solar energy and wind energy) have become important alternative sources of energy in the smart home. EVs are also becoming popular, because of their fuel efficiency and economic benefit, as compared to the conventional fuel-based vehicles. Energy management is an early target for similar verticals such as healthcare, agriculture, manufacturing, automotive, public transportation, utilities and energy, environmental, smart cities, and more. In energy vertical, it is crucial to find solutions to manage the peak demand while supporting substation automation of renewable energy systems such as DERs and EVs.The smart home energy management framework, i.e., EMA framework, must extend high-level communication that allow a bidirectional energy flow among energy systems including DERs and EVs [1]. In this context, control of the energy systems will allow the management of energy flow generated from DERs and EVs for consumption or for storage in the collective EVs.



ISO/IEC JTC1 SC25 standardized EMA that plays an important role to optimize the energy use of home appliances in smart homes by utilizing standardized two-way communication in home area networks (HAN). EMA is a self contained autonomous software agent for energy management by allocating/scheduling limited energy resources (e.g., thermostat) within residential and small buildings [2]. An EMA can be embedded in devices such as a thermostat, a smart appliance, or other consumer products such as EV charging system and distributed energy resources (DERs) [3]. EMA allocates energy among houses efficiently in a community and among appliances within houses, and to accommodate a choice of external or local or both energy sources linked to DERs or EVs [4]. External sources can be public utilities or DERs in other homes, possibly purchased using transactive energy. Local sources can include electric vehicles, renewable power generators and storage devices at the customer premises linked to its own EMA. Consumer devices linked to an EMA can interconnect logically via an EMA with local DER equipment such as generators (wind and solar) and energy storage devices (electric vehicle). In this system, EMA automatically react to DR events, while EVs are charged and discharged (i.e., V2G) in appropriate time slots by taking into account DR events, time-of-use rate information, and users’ vehicle usage plan. For realizing different levels of coordination, EMA is useful to optimize the energy use in smart homes by using EV as an emergency backup power when power outage occurs, and also it is beneficial for peak shift by charging EV in off-peak periods and discharging it in peak periods.

Each EMA enables the allocation of energy among appliances and switching energy sources from grid to local generation or storage according to consumer preferences [1]. EMA also enables automated demand-response (DR) services in a house, a residential community or a building consisting of multiple apartments for coordinating and allocating energy consumption and generation among multiple EMAs in different locations [6]. DR programs are being offered to residential consumers for energy conservation and for energy management to align demand for power with available supplies for appliance usage and budget constraints. The co-ordination among EMAs offers improved energy management and overall efficiency according to customer preferences.

Typical smart energy services can include integrated energy management for efficient energy usage. The coordinative energy management is a combination of DR services and distributed energy sharing and trading within the community, energy information sharing among multiple energy systems for more efficient energy usage, etc. These cooperative energy services offer benefits in electrical energy management in a house, a residential community or a building consisting of multiple apartments by energy sharing and trading among EMAs, EVs, DERs and home appliances [6].



*Figure N: EMAs for Cooperative Energy Management*

### EMA Protocol (EMAP) in Smart home integrated with EV charging

For Smart home integrated with EV charging, various standard communication protocols have been developed. For sending DR signals between grid and the home, OpenADR is often used as an application layer protocol. SEP 2.0 and ECHONET are application layer protocols for use in smart home. SAE J2836/J2847/J2931 and ISO/IEC 15118 are suites of standards of two-way digital communication between EV and EV supply equipment (EVSE) for smart charging and discharging control [7]. IEEE's standard 1547 is intended to mitigate many of these DER impacts by defining how DER devices are designed and tested, and how DER will be integrated into the power system.

EMA Protocol is a protocol to facilitate high-level communications among EMAs, EVs and DERs for cooperative energy management applications [5]. In this context, control of the energy systems will allow the management of energy flow generated from DERs and EVs for consumption or for storage in the collective EVs. The intent of EMAP is to accommodate flexible and efficient energy management systems according to the customer’s budget over a broad range of EMA deployments.

EMAP specifies message formats for energy related information including DERs, pricing, and DR commands to manage customer energy resources, including load, generation, and storage in a home, building and apartment complex. The message sets support direct load control, time-of-use (TOU), critical-peak-pricing (CPP), real-time pricing (RTP), peak time rebates, various types of block rates, transactive energy, charging, discharging and a range of opt-in, opt-out and service modifications. EMAP must support bi-directional exchange of DR event between EMAs for co-operative energy management by using the opt commands in a hierarchical or point-to-point architecture.

EMAP is an IEC-ISO application layer protocol among EMAs for cooperative energy management in smart home environment [5]. EMAP specifies interacting procedures and message formats to ensure interoperability over a broad range of EMA deployments. It also specifies a communication mechanism through which application layer messages based on UML based data modeling may be passed across EMAs.

EMAP gives a set of the message interactions for performing various functions and operations. The transport mechanisms rely upon standard-based IP communications, such as Constrained Application Protocol (CoAP) and JavaScript object notation (JSON) messaging: CoAP is a specialized Internet Application Protocol for devices with limited processing capability, as defined in RFC 7252[8]. It enables EMA devices to communicate with the Internet using similar protocols. CoAP is designed for use between devices on the same constrained network (e.g., low-power wireless home networks), between devices and general nodes on the Internet, and between devices on different constrained networks both joined by an internet. JSON is a public file format as defined in RFC 7159 that uses human-readable text to transmit data objects consisting of attribute–value pairs and array data types (or any other serializable value) [9]. It is a very common data format used for asynchronous browser–server communication.



*Figure N: High-level protocol architecture of EMAP*

### IEEE 802 Requirement for Integrating EV charging in an EMAP network

EMAP network requires the Development of an IEEE 802.11/TSN integrating smart home, DERs and EV charging system for cooperative energy management and control.

* Bidirectional data flow among Storages, DERs and EVs to support coordinated Energy Management and automation control (e.g., active and reactive power balance) in home microgrid.
* Regulation of power demand for the continuous balancing of generation, load, and interchange at a very granular level.
* Metering and sensing measurement for real-time control of power systems or microgrids

EMAP network requires evolution of IEEE 802.11/TSN for Electric Vehicle and Smart home Integration.

* To take advantage of the charging system and allow for a scalable approach while improving reliability and resilience in smart home with renewable energy sources.
* To take advantage of Collaboration and Coordination among smart home, DERs and EVs
* to compute charging schedules and to implement demand response and ancillary services [Collaborative Autonomy]

IEEE 802 provides a high number of wired and wireless solutions for the Physical and Link layer functions of communication links to serve a very wide range of interconnecting requirements of applications. Often the Generic IP protocol stack is used for realizing vertical applications, like HTTP, CoAP, or MQTT in the Application layer. IEEE 802 technologies allow for more specific network solutions when particular requirements or conditions arise. IEEE 802 standards allow the transmission of critical data in real time with a conventional Ethernet infrastructure in integrating smart home, DERs and EV charging system for cooperative energy management.



*Figure N: High-level protocol architecture of IEEE 802 based EMAP*

### Future IEEE 802 communication design (802.11 series vs. Ethernet vs. TSN) enables near real-time communications for Integrating EV charging in an EMAP network

IEEE 802.11p technology is the popular standard for vehicular networks, offering a coverage area of up to 1km, data rates of up to 54 Mbps and latency as low as 50 ms. IEEE 1609 “Wireless Access in Vehicular Environments (WAVE)" is a higher layer standard based on the IEEE 802.11p. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure, so called V2X communication, in the licensed ITS band of 5.9 GHz (5.85–5.925 GHz).

IEEE 802.11 is less expensive, supports mobility of devices, and its widespread prior adoption compared with other communication technologies is useful to equip the locations, such as parking areas, with wireless communication between EVs and CSs.

The significant advancement has been accomplished for the communication infrastructure with the special technologies that include the IEEE 1588 v2 or Precision Time Protocol (PTP) and Time-Sensitive Networking (TSN) standards to this area. These technologies are a clear evolution of the real-time control and allow synchronization levels of over few ms to be achieved.

TSN based LAN networks allow for higher levels of bandwidth utilization (75%) with lower latencies. TSNs were able to reduce this latency. With IEEE TSN’s ability to both synchronize timing for measurements as well as quickly move this data through a network, the feasibility of a large distributed state estimation system becomes more practical. It enables near real-time communications to request immediate energy consumption at the moment of generation or for use of the reserved energy to switch the energy systems from charging mode to power supply mode.

References

1. J. S. Choi, "Energy management agent frameworks: Scalable, flexible, and efficient architectures for 5G vertical industries," IEEE Industrial Electronics Magazine, vol. 15, no. 1, pp. 62-73, March 2021
2. ISO/IEC 15067-3:2012, Information technology – Home Electronic System (HES) application model – Part 3: Model of a demand-response energy management system for HES
3. ISO/IEC 15067-3-3:2019, Information technology – Home Electronic System (HES) application model – Part 3-3: Model of a system of interacting energy management agents (EMAs) for demand response energy management
4. ISO/IEC 15067-30:FIDS, Information technology – Home Electronic System (HES) application model – Part 30: EMA functional requirements and interfaces
5. ISO/IEC 15067-3-31:FDIS, Information technology – Home Electronic System (HES) application model – Part 3-31: Protocol of energy management agents for demand response energy management and interactions among these agents
6. J. S. Choi, "A hierarchical distributed energy management agent framework for smart homes, grids, and cities," IEEE Communications Magazine, Vol. 57, No. 7, pp. 113-119, 2019
7. T. Shimizu, T. Ono, W. Hirohashi, K. Kumita, and Y. Hayashi, “Experimental demonstration of smart charging and vehicle-to-home technologies for plugin electric vehicles coordinated with home energy management systems for automated demand response,” SAE International Journal of Passenger Cars-Electronic and Electrical Systems, vol. 9, no. 2016-01-0160, pp. 286–293, 2016.
8. IETF RFC 7252, The Constrained Application Protocol (CoAP), edited by Z. Shelby et al., June 2014, available at: <https://tools.ietf.org/rfc/rfc7252.txt> [viewed 2023-05-31]
9. IETF RFC 7159, The JavaScript Object Notation (JSON) Data Interchange Format, edited by T. Bray, March 2014, available at: https://tools.ietf.org/rfc/rfc7159.txt [viewed 2023-05-31]