EVSE Network Interoperability Standards
(An Overview)
Network Interoperability for EV Driver Roaming

Residential
- Single Family (SF) Residences
- Apt/Condo Complexes
- Student and Shared Housing
- Hotels/Resorts

Workplace
- Workplaces
- Customer Sites
- Fleet Vehicle Depots
- Universities and Schools

Public/Commercial
- Stores and Malls
- Inter-State Fueling Stations
- Airports and Hotels
- Downtown Workplaces

Charge at Different EV Charging Service Providers

Roaming is a Daily Recurring Need for Lifetime of Vehicle
**Gap 1: Charging of roaming EVs.** There is a need to permit roaming EVs to charge at spots affiliated with a different EVSP.

**Recommendation:** Develop communications standards that support roaming EVs that require charging services from an EVSP other than the EV users Home EVSP.

**Priority:** Near-term.

**Potential Developer:** SAE, ISO/IEC, Zigbee Alliance, OpenSG, NAESB, NEMA, others?

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**Gap 2: Locating and reserving a public charging station.** There is a need for a standardized communication method to permit EV drivers to locate a public charging spot and reserve its use in advance.

**Recommendation:** Develop a communication and messaging standard to permit EV drivers to universally locate and reserve a public charging spot.

**Priority:** Near-term.

**Potential Developer:** SAE, ISO/IEC, Zigbee Alliance, OpenSG, NEMA, others?

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**Gap 3: Offline access control at charging stations.** It would be beneficial to standardize offline access control at charging stations where a vehicle or driver may be denied access to charging.

**Recommendation:** Develop communication standards for offline access control at charging stations.

**Priority:** Near-term.

**Potential Developer:** SAE, ISO/IEC, Zigbee Alliance, OpenSG, NAESB, NEMA, others?
Overview & Summary

Critical Issues Affecting EV Usability

- Difficulty Locating Charging Stations Across Various EV Charging Service Providers (EVCSPs)
- Inconsistent and Incompatible Credentials and Activation Methods Prevents Drivers from Using Chargers Across EVCSPs
- Disparate and Non-Interoperable Charging Service Networks Prevent Drivers from Having Consolidated Charging Service Plans (Like Roaming Cell Phones)

Approach

- Create a Station Directory Data Schema and Protocol to Enable Sharing EVSE Attributes, Location, and Status Between Networks
- Define Standard Credentials and Service Activation Protocols To Enable Roaming and To Receive Charging Service On Any Standards Compliant Network
- Develop Communication Protocol Standards to Enable Authentication/Authorization, Conveyance of Charging Status, and Reconciliation of Customer Transactions

Proposed Solution

- ISO14443a/b RFID Credentials with ISO7816-4/8 APDU Messaging Layer
- Common EVSE Identification and Naming
- Charging Service Interworking Via Gateways to Adapt Internal Networks to a NEMA-Defined Internetwork Protocol
- Peer-to-Peer or Clearinghouse Connectivity
- HTTPS SOAP Based Protocol for Directory Data Sharing, Authentication/Authorization, Charging Status, and Billing Reconciliation
- XML Data Schemas and WSDL Specifications

Stakeholders

- National Standards Development Organizations (NEMA & ANSI) - Promoting Comprehensive National Solutions
- EVSE Manufacturers - Building Compatible Equipment
- EV Charging Service Providers - Interworking Their Networks to Enable Interoperable Charging Services Nationwide
- Local, State and National Governmental
A Collaborative EV Infrastructure Industry Effort

- NEMA & ANSI
- ChargePoint (WG Chair - Dan Lee)
- ECOtality / Blink Network (WG Vice-Chair - Colin Read)
- GE Energy
- Leviton Electric
- Siemens
- PEP Stations
- Eaton
- Schneider Electric
- ABB
- ... and Growing
Benefits of EVSE Network Roaming

Benefits to Drivers

- Greater Choice of EV Charging Stations Near Driving Destinations
- Improved Availability and Driving Range for EV Drivers
- More Economical EV Fueling from Product Standardization and “Coopetition”
- Much Needed Convenience to Drivers
  - Reduced Need to Sign Up for Multiple Charging Service Plans
  - Fewer Service Access Credentials To Be Carried Around
  - Fewer Mobile-Apps and Web-Sites to Visit to Find Available Charging Stations
- New Service Plans - Single Bill Electricity Service Plans Covering Home, Work, and Public Charging
- Commercial Fleet Management Services
  - Cost and Greenhouse Credit Management

Benefits to EV CSPs

- Increase Revenue From Your EV Charging Stations
- Drive More Consumers (with Long Shopping Times) to Host Store Locations
- Market an Expanded Service Foot Print to your Drivers and Hosts
- Enable Business Relationships Not Otherwise Possible with a Small Service Foot Print
- Encourage Smaller Mom & Pop Stores to Host EV Charging Services and Leverage “Network Effects”
- Retain Drivers/Subscribers by Providing a Better Driving Experience
**Inter- & Intra- Network Protocols**

**Areas of NEMA Standardization**

**Intra-Network Protocols**
- OCNP, OCPP
- Proprietary
- etc.

**Inter-Network Protocols**
- Directory ($I_D$)
- Authentication/Authorization ($I_A$)
- Charging Session ($I_C$)
- Billing ($I_B$)

**Compatible Driver-Side Interfaces**
- RFID ($U_R$)
- Station Identification Tags ($U_T$)

OSS: Operations Support Systems
BSS: Business Support Systems
Typical Driver Activity Flow

1.) Find Charging Stations Near Desired Location
   - Web, Mobile Phone, or Vehicle-Installed Telematics Applications

2a.) Authenticate and Activate Charging at Charging Station
   - RFID Application Specific Credentials
   - Payment Cards (Credit/Debit/Pre-Paid)
   - Vehicle Based Credentials (Future)

2b.) Send Activate Request from Home Network to Foreign Network
   - Mobile Phone Applications (Scan QR Code, Text Recognition, Manual Entry)
   - Web Applications
   - Customer Service

3.) Receive Record of Charging Activity and Pay for Transaction
EV Driver Roaming Use Cases (1/2)

- Supports Subscription Based Service Plans or Per Session Transactions
  - Simple & Fast Service Activation
  - Low Transaction Overhead
- Enables Supplementary Services
  - Charging Status Notifications (EV Charging Done/Interrupted)
  - Usage Data and Receipts
  - Other Value Added Services May Help Subsidize Charging Costs
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EV Driver Roaming Use Cases (2/2)

Home Network

- Home-Network Initiated (Mobile App)
- Home-Network Initiated (Others)
- Directory/Maps

Visited Network

- Charge Data
- Billing
- Other Services

GWY

IA / IC / IB

UT

IA / IC / IB

- Web-App
- Customer Service Call
- Others

Home-Network Initiated
(Mobile App)

Home-Network Initiated
(Others)

Home NOC

GWY

Home NOC

Home NOC

GWY

Home NOC

GWY

Home NOC

GWY

Home NOC

GWY

Home NOC

GWY

Home NOC

GWY

Home NOC

GWY

Home NOC

GWY

Home NOC

GWY
Payments-Based Use Cases

**Home Network**
- Simple Transactions, Non-Roaming
- Payment Cards
  - Home NOC

**Visited Network**
- Payments
  - Gateways
  - Acquirers
  - Interchange
  - Banks
- Pre-Authorization
- Settlement
- MagStripe Contactless (PayPass, PayWave)
- PayPass PayWave EMV (NFC Loyalty)
- (Other Services)

For Further Study

Payment Cards
- Home NOC
- (NFC Loyalty)
- (Charging Data)
- (Other Services)
Use Cases For Further Study (1/2)

**Home Network**
- Vehicle Telematics Initiated
- Telematics Service
- For Further Study

**Visited Network**
- Telematics App
- Activate (Proprietary)
- $I_A$, $I_C$, $I_B$
- Authorization
- Charging Data
- Billing
- (Other Services)

**For Further Study**
- Vehicle Initiated
- Home NOC
- PLC / ISO15118
- $U_V$
Use Cases For Further Study (2/2)

For Further Study

- Standardize Information Needed to Input Driver Account and Token Information
  - One-Time Token May Be Retrieved Out-of-Band
  - One-Time Token May Be Auto-Generated by Mobile-App
  - Not Intended to Standardize EVSE User Interface
  - Token To Be Included in Authentication Message
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Interface Standardization Reference Points

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**Driver Interface**

- RFID
- Vehicle
- Station Id Tags

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**Inter-Operator Interface**

- Directory
- Authentication
- Charging
- Billing

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- Station Directory ($I_D$) Provides an Integrated View of Stations on Participating Networks Along with Real-Time Status
- Common Station Station Identification ($U_T$), Subscriber RFID Credentials ($U_R$), and Authentication Protocols ($I_A$) Enable Service Activation Across Any Network
- Roaming Service with Charging Status and Billing Across Networks ($I_C$ and $I_B$)
Station Directory Data Schema & Protocol ($I_D$)

- **Standardize Data Exchange Protocol, But Not Presentation of Data**
  - Each EVCSP To Differentiate Its User (Mobile) Apps

- **Give Consumers Information To Choose According to Their Needs**
  - Proximity & Realtime Availability of Charging Service
    - Location and Site Picture Information
    - Potential for Electricity Delivery Curtailments
  - Type of Charging Service
    - Number of Ports / Per-Port Charging Level Types / Total Power Delivery Capability
    - Parking Characteristics (with Possibility of Conveying Parking Sensor State Information)
  - Price of Service
    - Time-Based Parking Fees / Electricity Usage Fees / Session Fees
    - Payment Types (Network-Specific Credentials, Payment Cards, Cash, etc.)

- **Give Charging Stations Hosts/Owners Flexibility To Design Their Service Offering**
  - Allow Hosts/Owners to Respond to Different Market Conditions

- **SOAP/WSDL/XSD Implementation**
Primary Station Directory XSD Elements

*EvseInfo (Pseudo-Static Data)*
- IdentificationInfo / OperatorInfo / LocationInfo / AccessInfo
- ChargerPort
- ParkingSpot
- SessionFee / ElectricityFee / ParkingFee / OtherFee
- PaymentMethod

*EvseStatus (Near-Realtime Data)*
- ChargerPortStatus
- ParkingSpotStatus

*EvseSearchParameters (Search Interface)*
- By Location
- By EvseInfo Data Attributes
RFID Authentication ($U_R$ and $I_A$)

- **Card (Driver)**
  - ISO 14443a/b
  - ISO 7816-4/8

- **Station (Reader)**
  - Select Card Application
  - Select R-APDU Data
  - Read Record
  - Static Card Data {VER,CID}
  - Challenge {SID,TS,RN}
  - Response {Cryptogram}
  - e.g., $\text{Encrypt}_{\text{Key}}(\text{SID,TS,RN,CID,CTR})$

- **GW**
  - Authenticate
    - $(\text{SID,TS,RN,Cryptogram},\text{SessionId})$
  - De-Select

- **Visited Network**
  - Recognize NID as being from a different Issuer.

- **Home Network**
  - {CardId, Key} Pairs Or Diversified MasterKey
  - Verify Cryptogram: $\text{Decrypt}_{\text{Key}}(\text{SID,TS,RN, Cryptogram,SessionId})$ and Compare

- **Authorize**
  - $(\text{Accept/Reject,SessionId,MaxCharge,etc.})$

- **Authorize**
  - $(\text{SessionId,Allow/Reject,TransAct#,MaxCharge})$

- **Note:** Secret Key Never Disclosed; Only Cryptogram is Sent.

- **VER:** Version Info
- **NID:** Network Id
- **CID:** Card Identifier
- **TS:** TimeStamp
- **RN:** Random Number Nonce
- **SID:** Station+Network Id
- **CTR:** Counter for Replay Detection

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Authorize
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Authentication & Authorization (I_A) - Proposed Msgs

- **Authenticate**
  - Request to Authenticate a Credential Presented on the Foreign Network
  - Challenge/Response Data Carried in Msg.

- **Authorization**
  - A Response to the Authenticate Msg.
  - The Response Includes a Digitally Signed Ticket Authorizing Service
  - Authorization Can Be Rejected for Any Reason (Invalid Credential, Insufficient Funds, Un-Supported Network, …)

- **Authorized**
  - Acknowledge Receipt of the Authorization Ticket
  - Indicates Ticket Was Received By Foreign Network and Was Accepted
  - Also Indicates Ticket Was Not Acceptable/Invalid

![Diagram of Authentication & Authorization](image-url)
Charging Session ($I_C$) - Proposed Msgs

- **SessionEvent(Started)**
  - Indicates Session Was Started (Typically by the J1772 State Change or Other Sensor”)

- **SessionEvent(Update)**
  - A Message Providing the Home Network with an Update to the Charging Session Utilization Data

- **SessionEvent(Fault)**
  - An Event Occurred on the Session (e.g., GFCI Fault or Demand-Response Action)

- **SessionEvent(Ended)**
  - Session Was Ended by the Foreign Network

- **SessionQuery**
  - Allows the Home Network To Query for the Current Status of the Session

- **SessionStatus**
  - Gives Status of a Session

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Diagram:

- **Foreign Network**
  - GW
  - SessionEvent(Started)
  - SessionEvent(Update)
  - SessionEvent(Update)
  - SessionEvent(Ended)

- **Home Network**
  - GW

- **Charging**
  - $I_C$
  - SessionQuery
  - SessionStatus
  - SessionEvent (Fault-Active)
  - SessionEvent (Fault-Cleared)

- **Service Interruption**
  - Normal Flow
  - Query Status
Implementation Architectures

Centralized Clearing House

- EVCSP Network
- Clearing House
- EVCSP Network
- EVCSP Network

Peer-to-Peer Inter-Connection

- EVCSP Network
- EVCSP Network
- EVCSP Network
- EVCSP Network
Standards Development Timeline

Project Start

July 2012

2012/Q4 2013 2013/Q1 2013/Q2 2013/Q3 2013/Q4 2014

I_D - Station Directory Schema & Protocol (Draft)

2012/Q4 2013

U_R - RFID Protocol (Draft) U_T - Station Id Tag Spec. (Draft)

I_A / I_C / I_B Inter-Operator Protocols (Draft)

[ Revisions and Test Implementations ]

Protocols In Final Form For Comments & Balloting