Welcome!

- Thank you for joining today's webinar: **Developing and Applying Open-Source Implementations of OpenADR**
- If you have a question please use the question box located on the right side of your screen.
- Questions for our speaker will be addressed at the end of the presentation.
- This webinar will be recorded for future playback.

openADR ALLIANCE

Today's Speakers

- Walt Johnson is a Technical Executive at the Electric Power Research Institute (EPRI), where he specializes in smart grid technologies, standards, and IT Enterprise Architecture.

  He manages EPRI's Automated Demand Response and Ancillary Services Demonstration Project, supports the Transmission and Distribution Modernization Demonstration Projects on Data Analytics, and leads the new ICT Innovators Forum.

  Prior to joining EPRI, Walt spent nearly ten years at the California Independent System Operator (CAISO), during which time he served on the Technical Advisory Group for LBNL's original AutoDR/OpenADR project.

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

Developing and Applying Open-Source Implementations of OpenADR

Walt Johnson
Technical Executive

OpenADR Alliance Webcast
March 24, 2015

Today's Presentation

- What We'll Talk About
  - The EPRI Project
    - What, why, who,…
  - The EPRI Software
    - Who, what, how, where,…
  - Deployments
    - Project demos, other EPRI projects, commercial service
  - Software Enhancements
- What We Won't Talk About
  - Demand Response (in general)
  - The OpenADR Specification
    - History, profiles, services, signal types,…
  - Other ADR Standards
    - IRC WDRCP, IEC, SEP2,…
  - How to use the EPRI Software

The Electric Power Research Institute

Independent

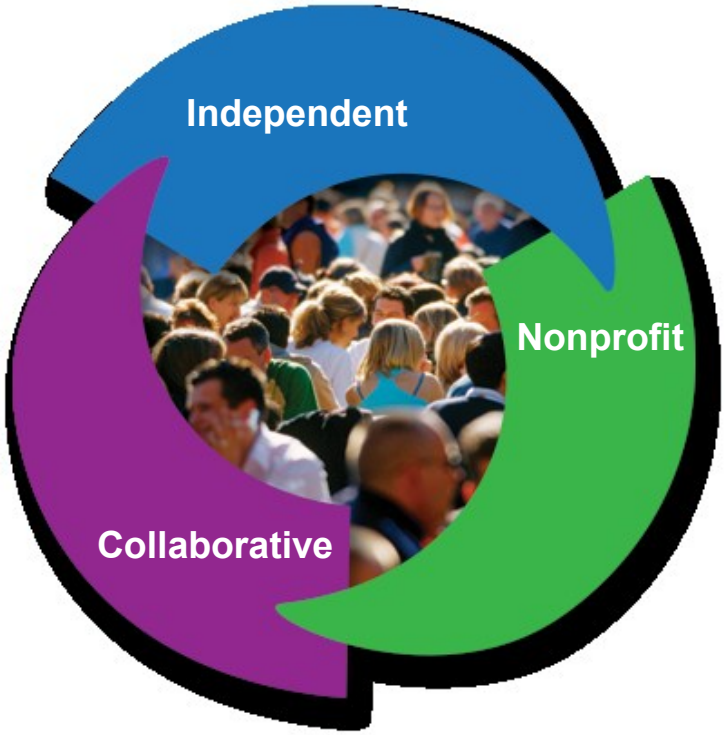
Objective, scientifically-based results addressing reliability, efficiency, affordability, health, safety and the environment

Nonprofit

Chartered to serve the public benefit

Collaborative

Bringing together scientists, engineers, academic researchers, and industry expe



Together… Shaping the Future of Electricity

The EPRI Project

"Automated Demand Response and Ancillary Services Demonstration"

OpenADR Project Activities

EPRI Project Demonstrations

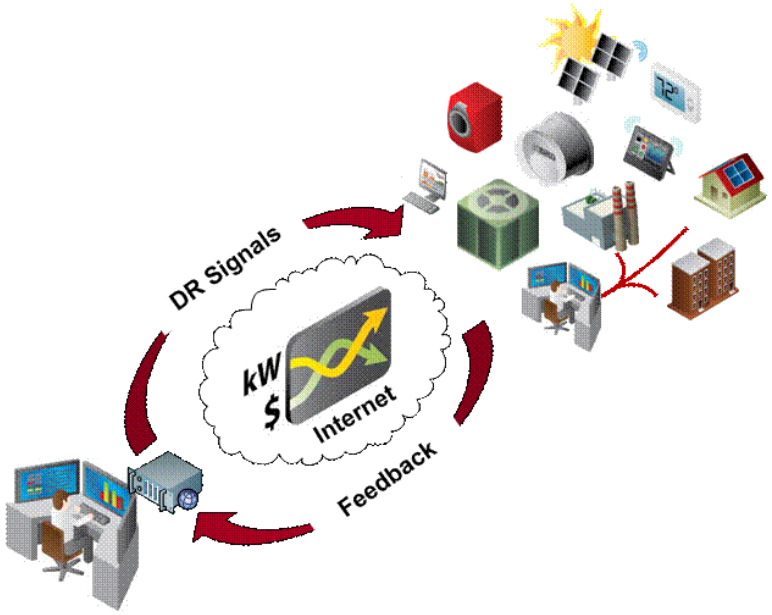
- **ISOs:** CAISO and NYISO
- **US Utilities**: AEP, KCPL, SDG&E, Southern Co.
- **International Utilities**: ESB Networks (Ireland), EdF (France), TEPCO (Japan)

Other Deployments in Progress

- California Utilities
- LBNL
- OpenADR Alliance (~100 Members)
- Other EPRI Activities

International Adoption

- Now an IEC Publicly Available Specification (PAS)



Virtual Top Node (VTN) - Server
http://sourceforge.net/projects/openadr2vtn/

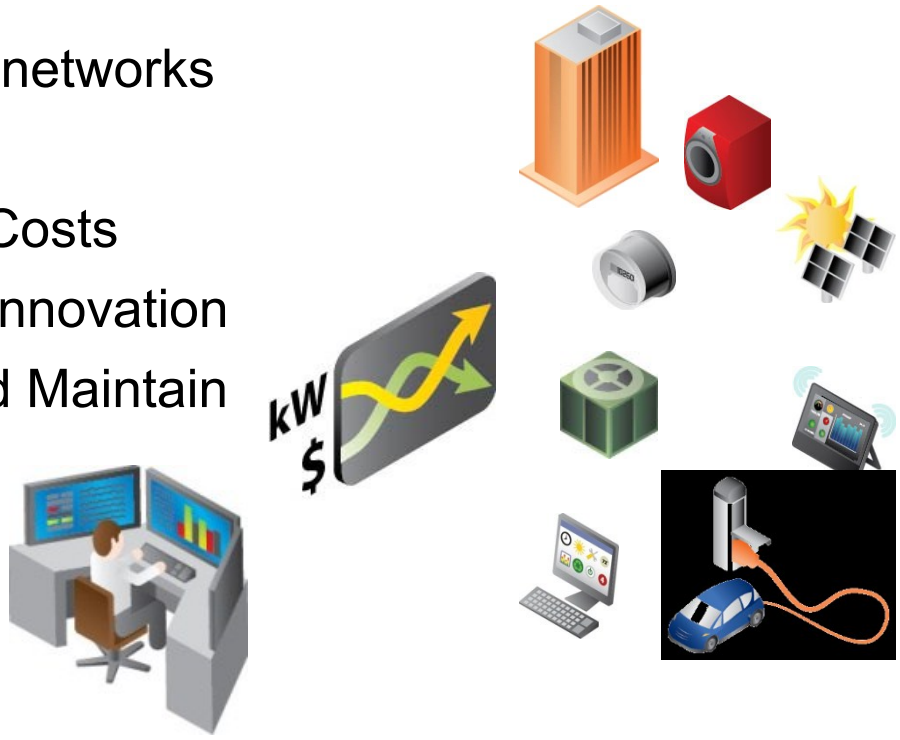
Virtual End Node (VEN) - Standalone Client
http://sourceforge.net/projects/openadr2bven-pull/

Virtual End Node (VEN) - Client Library
http://sourceforge.net/projects/openadrvenclibrary/

EPRI Open-Source Contribution Accelerating Adoption; Significant Global Impact

Drivers - Benefits of Standardized DR/DER Messaging

- Interoperability for Pricing and DR Events (Utilities and ISOs)
- Commercial Off-The-Shelf (COTS) Products
- Increased Operational Efficiency, Reliability, and Security
  - "Fast DR" and ancillary services
  - Use of low-cost communications networks
- Lower Design and Installation Costs
- Lower Operation and Maintenance Costs
- New Services through Competitive Innovation
- Larger Pool of Talent to Support and Maintain Standardized Systems



EPRI's OpenADR Development

EPRI developed the open-source software to:

- Gain familiarity with the standard
  - Profile A and B capabilities
  - Relationship between VTNs and VENs
- Provide EPRI project host sites access to 2.0 software
- Provide utilities and suppliers with source code to develop and test with programs and other products
- Because specifications can be tested *only* through implementations

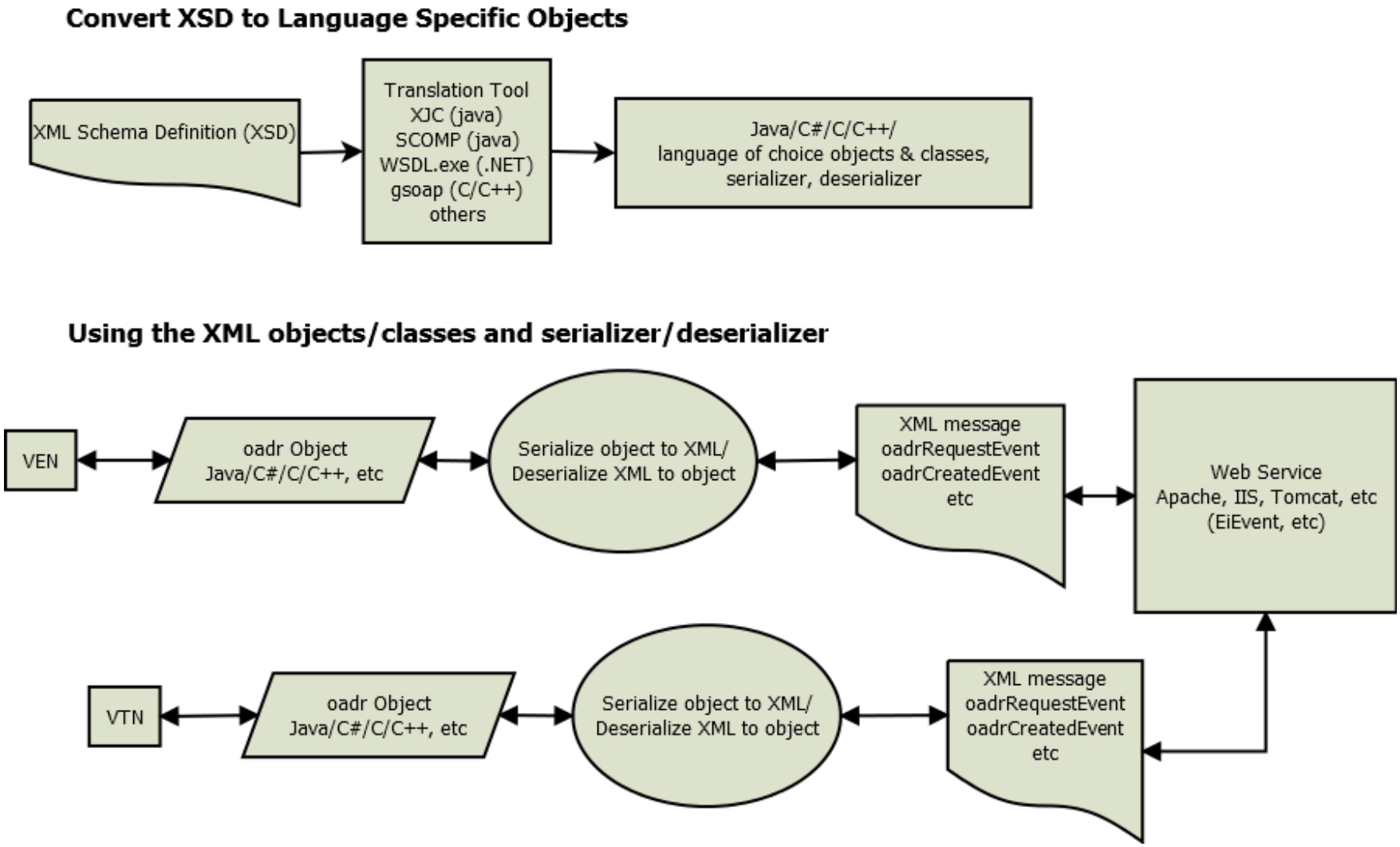
Why Make the Software Open Source?

By providing the source code, EPRI hopes that:

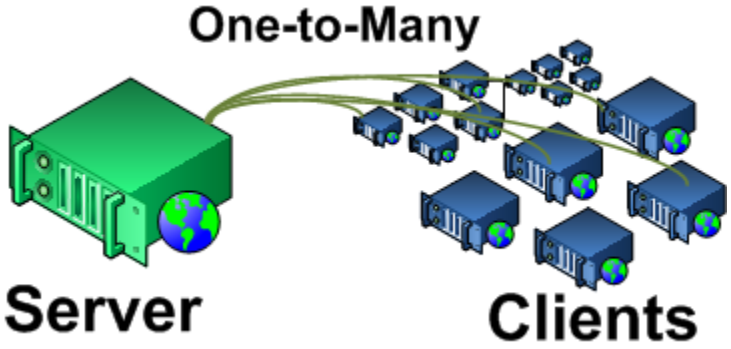
- Utilities will test OpenADR with their DR programs
  - Reducing costs to deploy pilots
  - Increasing internal knowledge
  - More deployments lead to a competitive VEN marketplace
- The specification will be improved by providing to working group knowledge gained from deployments

Architectural Requirements for an OpenADR Implementation

XML Messages



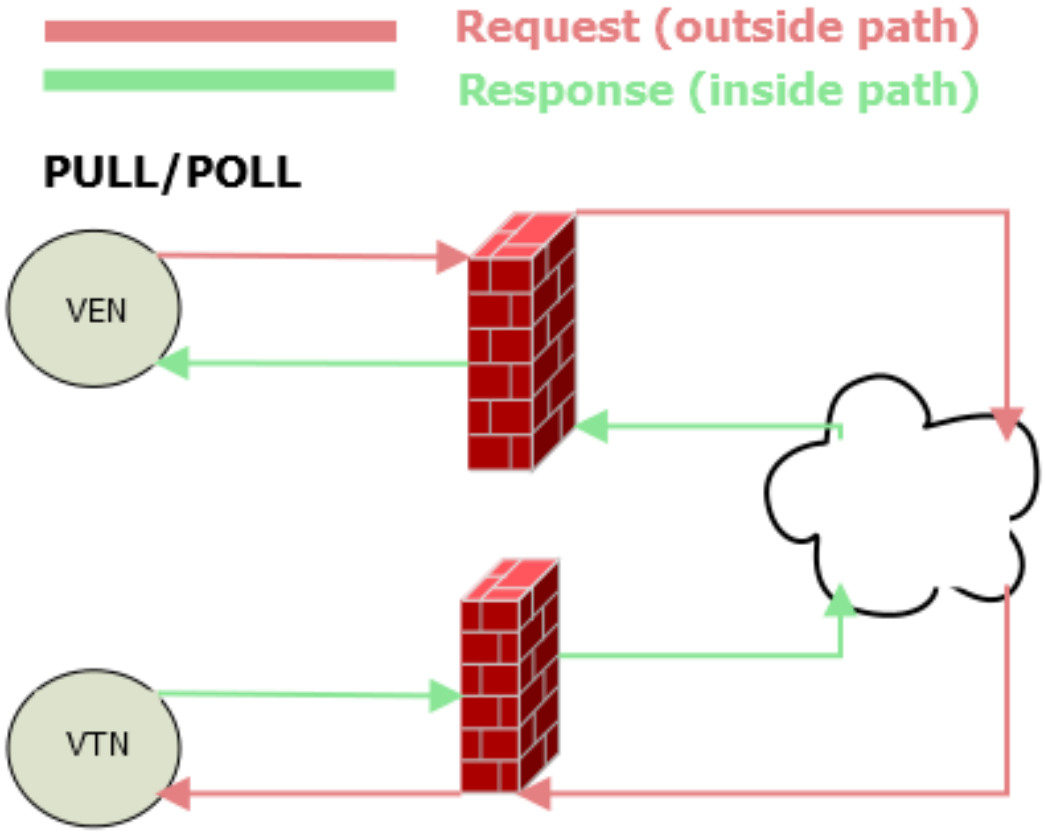
Client/Server Architecture



- VTN – Virtual Top Node (typically the server)
- VEN – Virtual End Node (typically the client)
- The client/server model is a good fit for a DR program, where a single authority (operating the VTN) calls events to manage load at many clients (though the VENs)
- The Push model used in OpenADR allows a VTN to push data to a VEN; but note that although this is still a client/server design, the VTN acts as an HTTP *client* and the VEN acts as an HTTP *server*

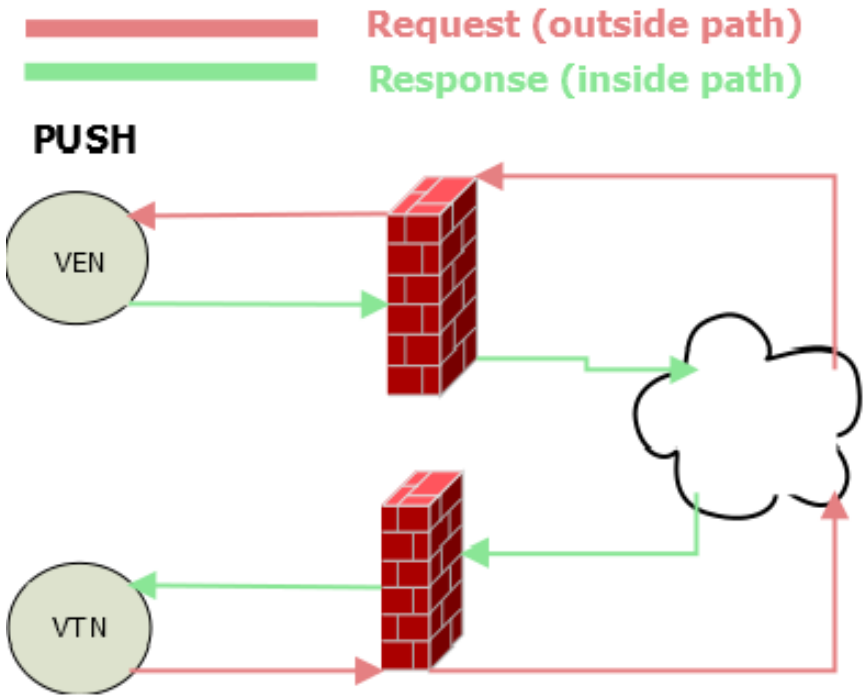
Pull/Poll Messaging

- Pull and Poll are the same interaction between the VTN and the VEN
- The VEN initiates the request and the VTN responds



Push Messaging

- The VTN (server) initiates the exchange when it sends to the VEN (client)
- The VEN must register a Push endpoint with the VTN (this is an out-of-band process for Profile A)
- Push can provide a faster mechanism for communicating with clients
- Additional firewall ports might need to be opened to provide access from the VTN to the VEN



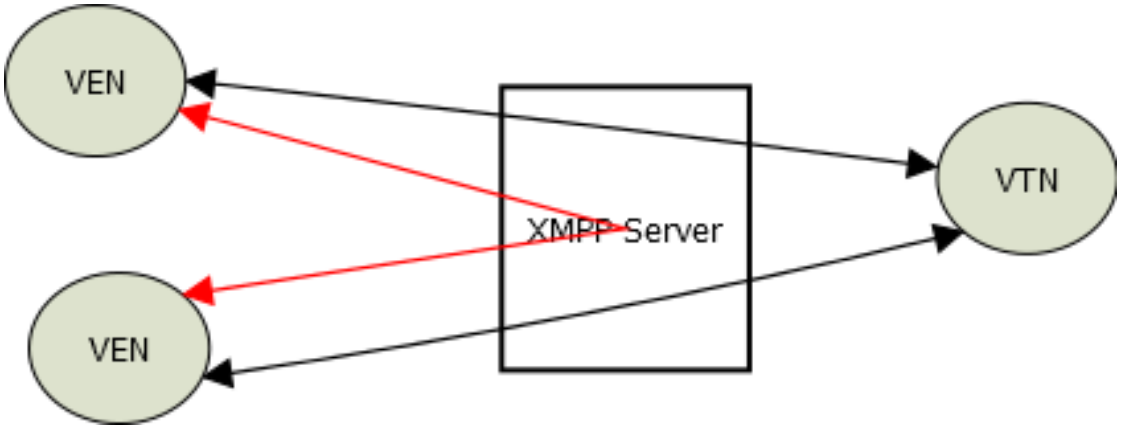
Transport and Security Requirements

Transport Choices

- Transport mechanism must be selected for the data exchanges
  - VTNs must support all (both) transport mechanisms
  - VENs can select one transport mechanism
- EPRI selected a simple HTTP implementation to begin
- XMPP (Extensible Messaging and Presence Protocol) is also specified
- Some OpenADR Alliance members are using Openfire (http://www.igniterealtime.org/projects/openfire/)
  - An open-source XMPP implementation
  - EPRI's implementation uses this as well

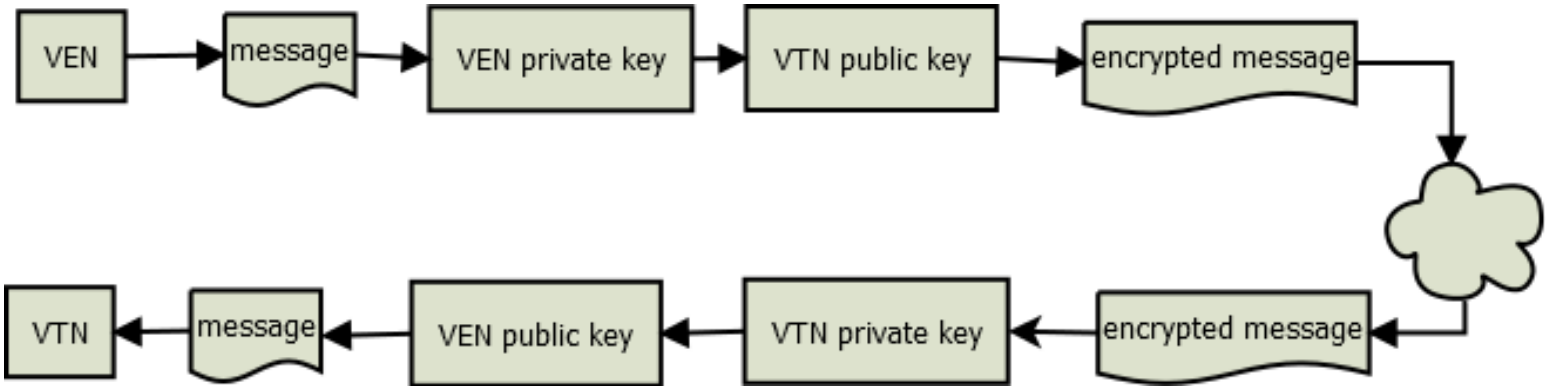
Transport Implementation

- Simple HTTP
  - All messages use POST to avoid caching (and other issues)
  - The XML payload is the message body in the HTTP request
  - The service name is appended to the endpoint
  - Example: http://.../oadr2a-vtn/OpenADR2/Simple/EiEvent
- XMPP
  - Inherently two-way



Public Key Cryptography

- Works with public/private key pairs
- Public key is shared with all, the private key is kept private
- If a public key is used to encrypt, only the private key can decrypt (and vice-versa)



Conformance and Certification

Certification Requirements

- Certification requires adhering to:
  - Profile conformance rules
  - PICS (Protocol Implementation Conformance Statement)
- Managed by OpenADR Alliance
- Product must be tested by an authorized test service provider. Intertek (http://www.intertek.com/) is the testing and certification laboratory for the OpenADR Alliance
- Must be alliance member to have certificated products

Note: Use of EPRI's Alliance-certified software to create a new application does *not* confer certification on the resulting application. All applications are individually certified by the OpenADR Alliance.

Conformance Rules: Sample from Profile B (draft)

ce Rule	
100	**VTN, EiEvent Service, oadrDistributeEvent Payload** For both eiEventSignal and eiEventBaseline the following substitution group items shall be used: • streamPayloadBase = signalPayload • payloadBase = payloadFloat The number of signalPayload elements in each interval must be equal to 1.
101	**VTN, EiEvent Service, oadrDistributeEvent Payload** The uid element is required for each eiEventBaseline interval. Within a single eiEventBaseline, uid must be expressed as an interval number with a base of 0 and an increment of 1 for each subsequent interval.
102	**VTN, EiEvent Service, oadrDistributeEvent Payload** For both eiEventSignal and eiEventBaseline, the interval duration element must appear in each interval and the sum of interval durations must add up to overall duration element specified immediately in eiActivePeriod:properties:duration for event signals and eiEventSignal:eiEventBaseline:duration for baselines.
103	**VTN, EiEvent Service, oadrDistributeEvent Payload** For both eiEventSignal and eiEventBaseline, the dtstart element shall NOT be included in the interval specification.

- OpenADR_2_0b_Profile_Specification_v0_9_20130318.pdf

Conformance Rules: PICS

- Questionnaire filled out by manufacturer
- A series of yes/no questions
- Released to the public, it provides an idea of what's supported by the implementation and any limitations

Core Operation Payload Schema Conformance

For each payload generated by an implementation, indicate if it conforms to the indicated schema.

Item	Requirement	Reference	Support
1	oadrDistributeEvent validates against the Alliance "A" profile schema	Alliance Schema	[ ]Yes [ ]No [ ]N/A
2	oadriCreatedEvent validates against the Alliance "A" profile schema	Alliance Schema	[ ]Yes [ ]No [ ]N/A
3	oadrRequestEvent validates against the Alliance "A" profile schema	Alliance Schema	[ ]Yes [ ]No [ ]N/A
4	oardResponse validates against the Alliance "A" profile schema	Alliance Schema	[ ]Yes [ ]No [ ]N/A

Note: VTNs generate items 1 and 4, Push VENs item 2, and Pull VENs items 2 and 3.

- OADR 2.0a PICS_v1_0_4.docx (comes with TestSet purchase)

Conformance Rules: TestSet

- The Alliance provides the TestSet (for a fee)
- The TestSet has many test cases for testing conformance rules
- The TestSet documentation shows which test cases exercise which conformance rules

Appendix B – Conformance Rules to Test Case Mapping

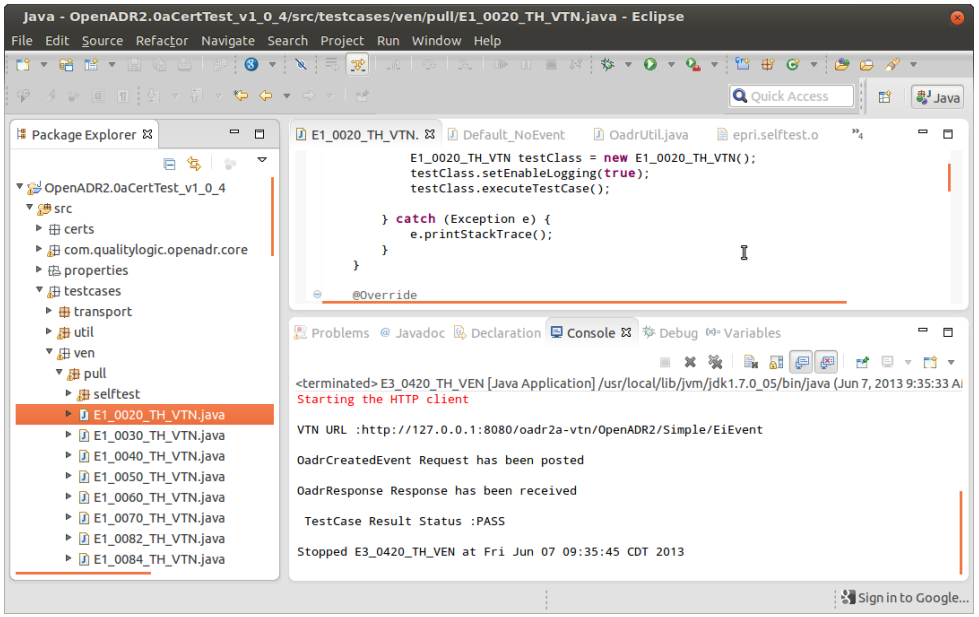
The following table is a cross reference between alliance specific conformance rules and test cases that validate their conformance. Refer to section 11.2 of the OpenADR Alliance 2.0a Profile Specification for detailed descriptions of each conformance rule.

Conformance Rule	Test Cases
1	-Proper format validated on each payload by schema validation
2	-Validated by Conformance Rule 2 Payload Validation (see Appendix A)
3	-E0 & E1 = 0250, 285 -E2 & E3 = 510, 520 -Validated by Conformance Rule 15 Payload Validation (see Appendix A)
4	-E2 & E3 = 0452
5	-E2 & E3 = 0470. 0474, 0476, 0478. 0480, 0490, 0492, 0494, 0496, 0498
6	-E0 & E1 = 0130
7	-Validated by Conformance Rule 7 Payload Validation (see Appendix A)
8	-Validated by Conformance Rule 8 Payload Validation (see Appendix A)
9	-Validated by Conformance Rule 9 Payload Validation (see Appendix A)

- OpenADR_2_0b_Profile_Specification_v0_9_20130318.pdf

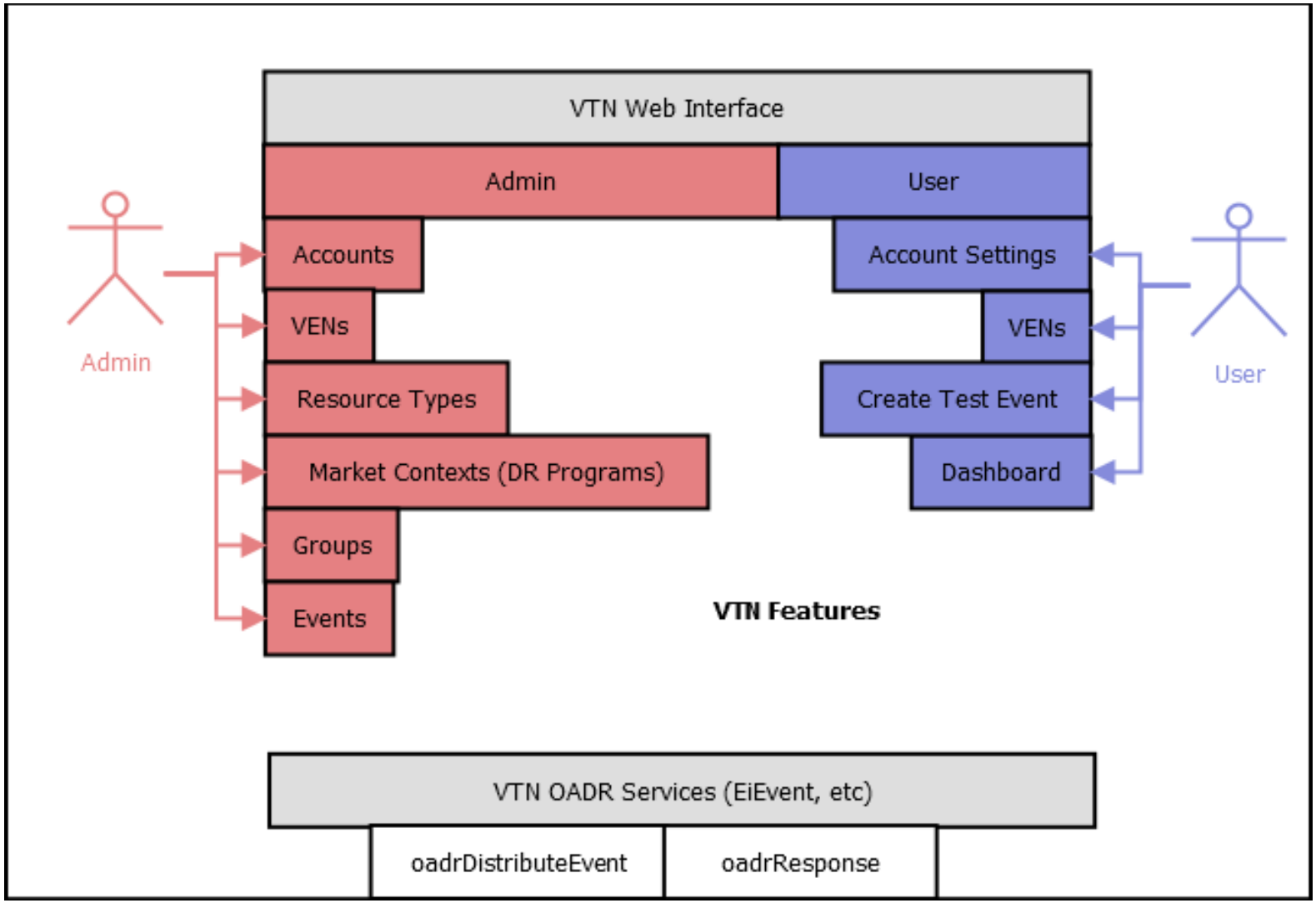
Conformance Rules: TestSet

- A Java-based program written with Eclipse
- Developed and maintained by QualityLogic
- Contains many push and pull tests for VENs and VTNs
- Sends test messages to a VTN and validates the response
- Receives test messages from a VEN and validates the response

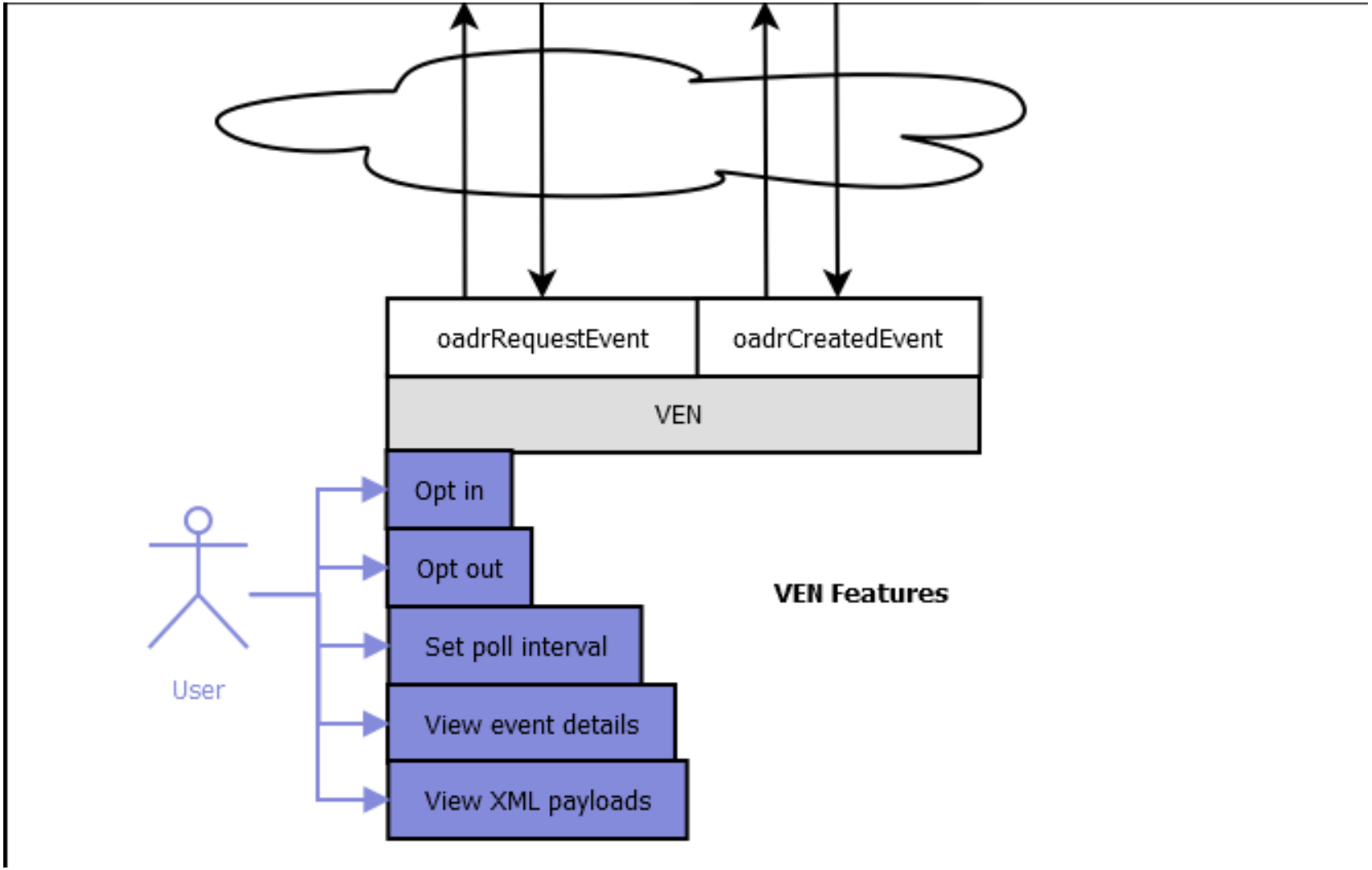


The EPRI Software

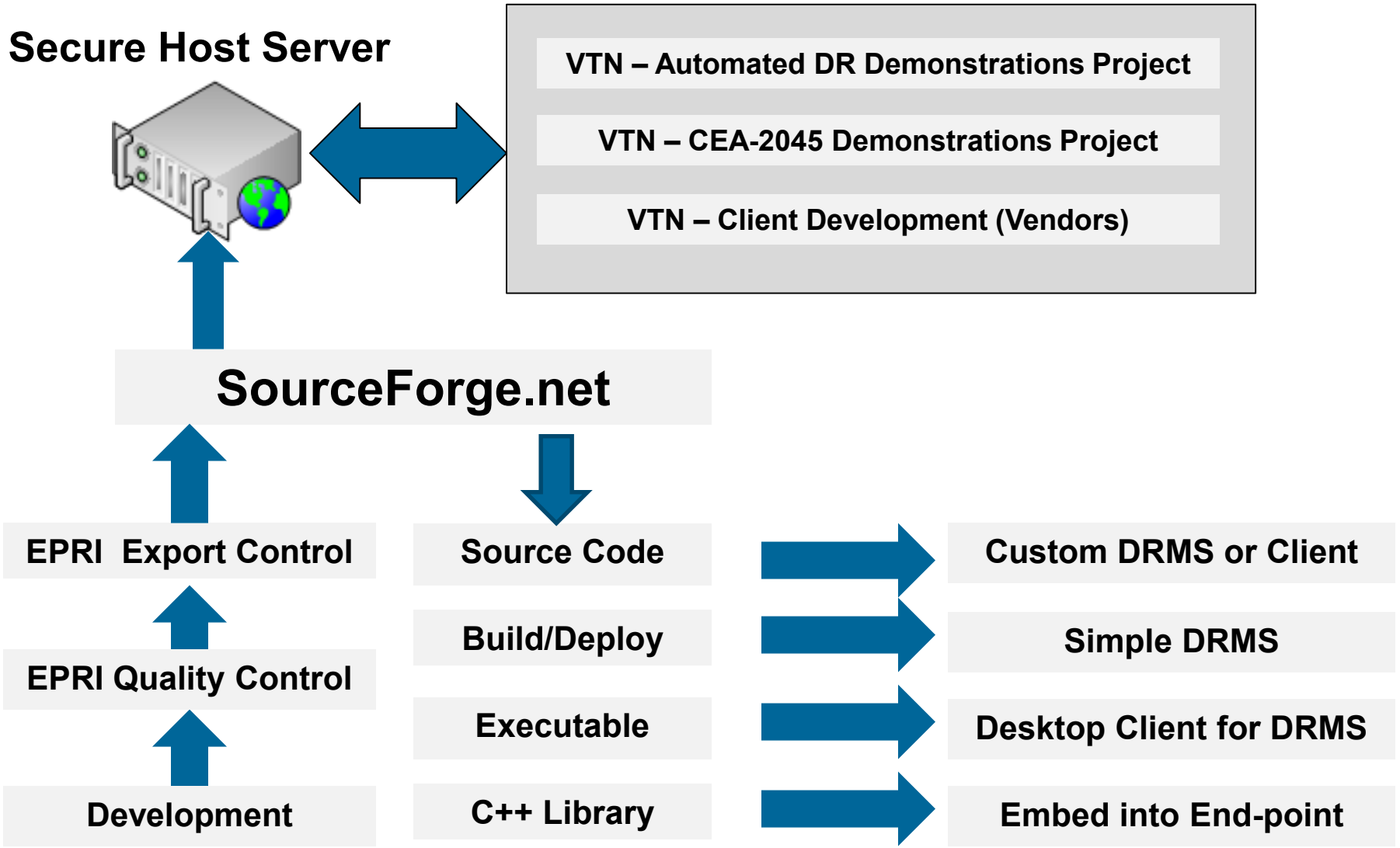
VTN Functions



VEN Functions

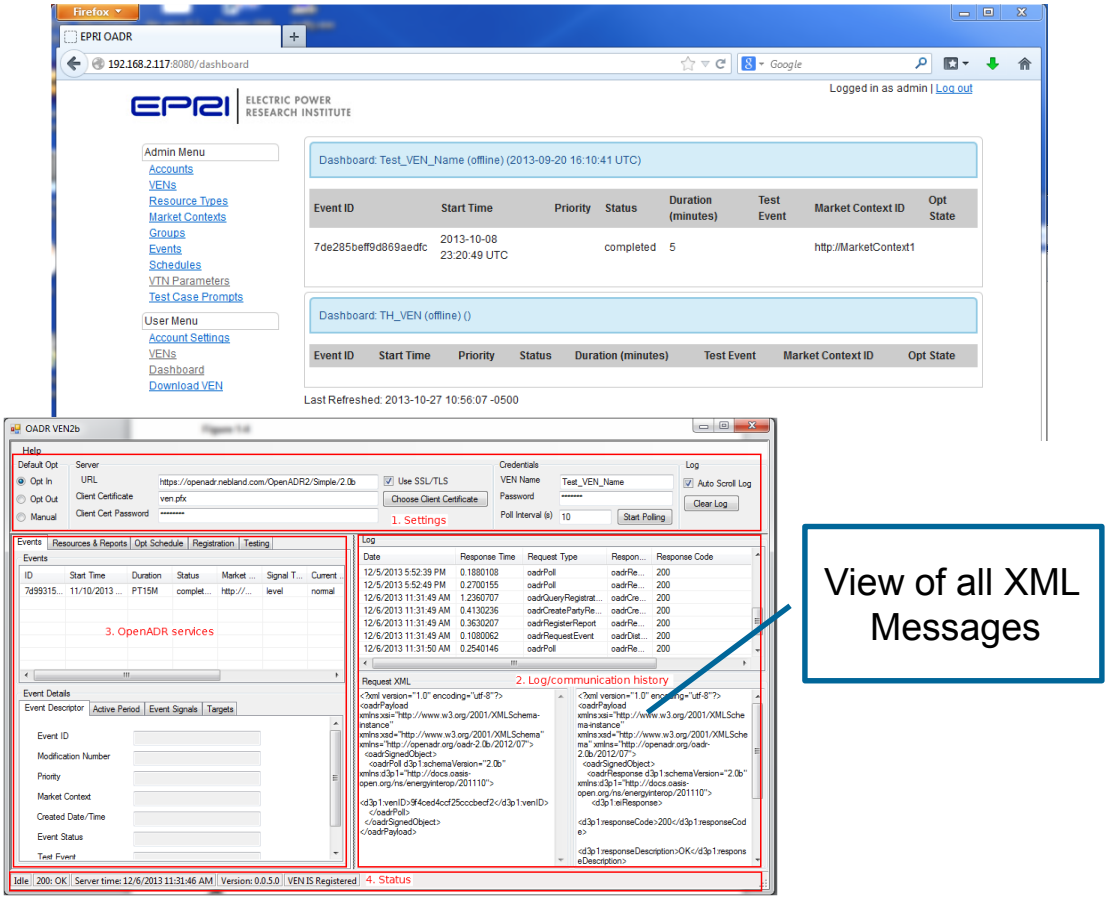


EPRI's OpenADR 2.0b Open-Source Processes



Virtual Top Node (VTN) and Virtual End Node (VEN)

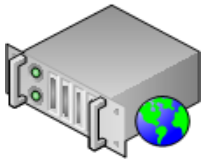
- Complete OpenADR 2.0b-compliant server and standalone client
- Made available to the open source community in February 2014
- Received certification in October 2014
- Posted certified versions in December 2014



C++ End-Node Library

- Implements the functions of an OpenADR 2.0b HTTP Pull VEN
- Generates compliant messages for all four Profile B services
- Manages HTTP/s connection using cURL and OpenSSL libraries
- Can be used to create a compliant VEN
- Intended for embedded applications

OpenADR 2.0b Open-Source Software

	 VTN	 VEN	 VEN
Role	Virtual Top Node	Virtual End Node	Virtual End Node
Designed Use	DRMS	Desktop Client	Embedded Client
License	BSD 3-Clause	BSD 3-Clause	BSD 3-Clause
Profiles	2.0a and 2.0b	2.0b	2.0b
Data Models	Push & Pull (Poll)	Pull (Poll)	Pull (Poll)
Transports	HTTP, XMPP	HTTP	HTTP
Programming Language	JRuby, Java	C#	C++
Tested Operating Systems	Linux, Mac OS	Windows 7, 8	C++
Available on www.SourceForge.net	Yes	Yes	Yes

EPRI OpenADR-Related Projects

California ISO (CAISO) Demonstration

California ISO
Your Link to Power

Research Questions

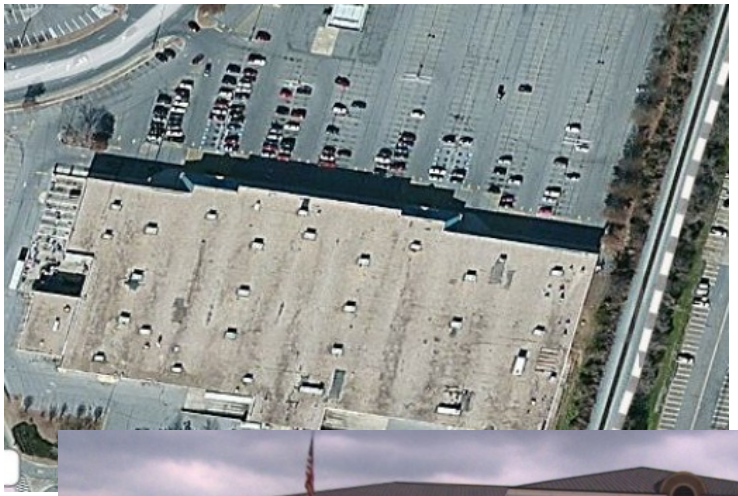
- Could OpenADR be used to support an existing “Fast DR” wholesale demand response program (Proxy Demand Resource – PDR)?
- What building loads should be targeted?
- How should the targeted loads be operated to optimize shed potential?
- Could an OpenADR 2.0 VEN be integrated with the building management system?

EPRI ELECTRIC POWER RESEARCH INSTITUTE

Southern Company Demonstration

Research Questions

- How can OpenADR be integrated into legacy buildings?
- Could OpenADR support a real-time price signal?
- How does OpenADR support critical peak price signals?
- How would building loads respond to these signals?
- What loads should be targeted?



ESB Networks Demonstration

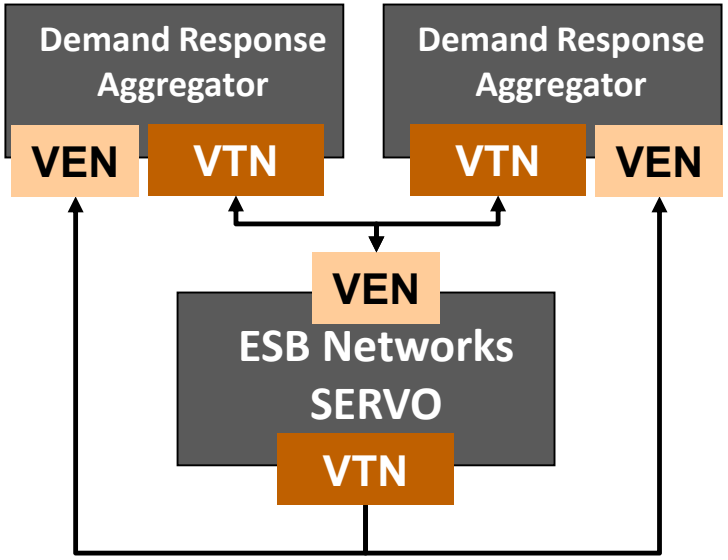
Targeted Demand Response

Proof-of-concept DR Program Architecture

- Experiment is designed to process proposed third-party demand response signals in near-real time

Use of OpenADR 2.0

- Interface between SERVO and DR Aggregator
- Designed to manage LV and HV network constraints while at the same time equitably managing customer participation
- Experiment uses OpenADR source code developed under this project

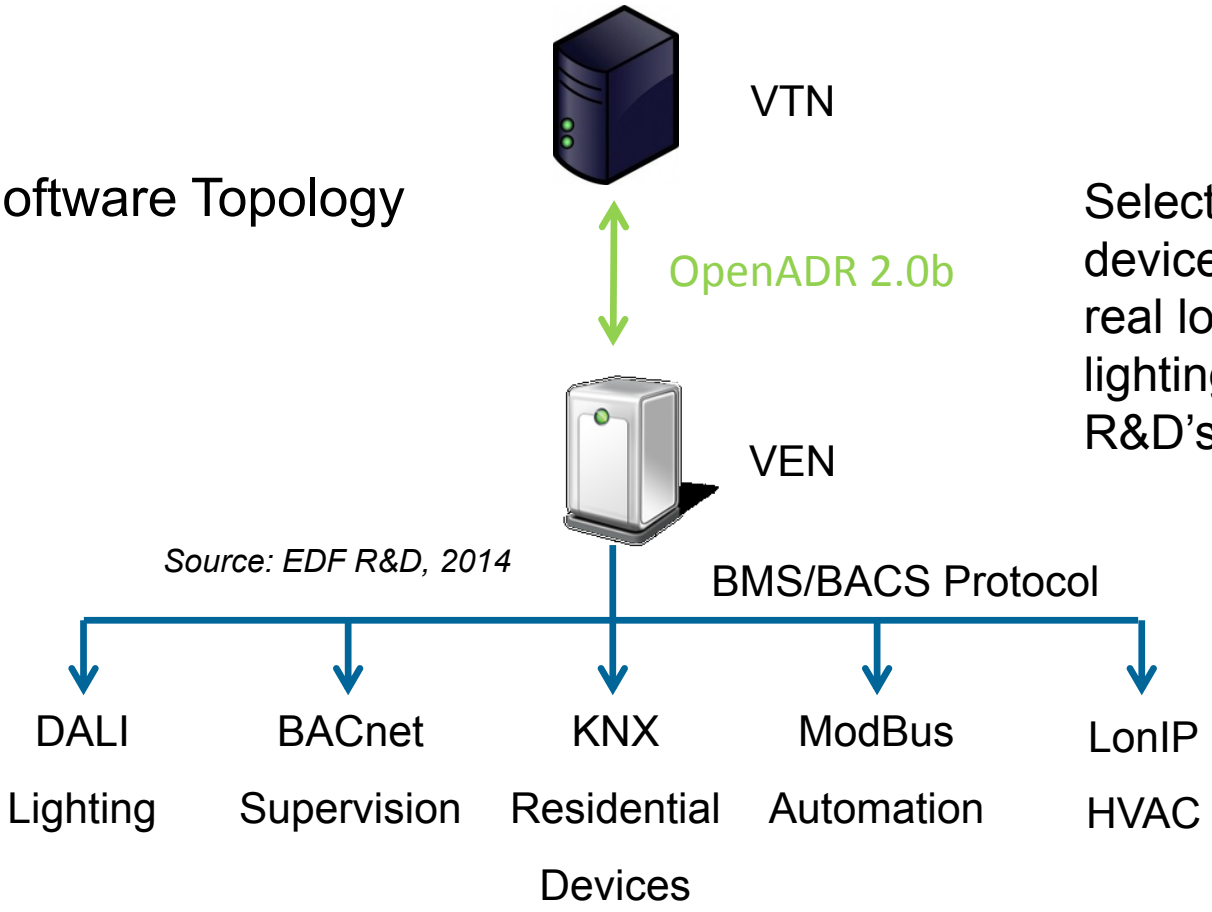


Managing Network Constraints using OpenADR

EDF: End-to-End Testing using OpenADR2.0b Devices

OpenADR 2.0b server (VTN) and client (VEN) developed by EPRI

Software Topology



Source: EDF R&D, 2014

Selected OpenADR 2.0b end devices will be connected to real loads (heater, water heater, lighting, air conditioning) in EDF R&D's labs

Future Developments

- Other EPRI OpenADR-Related Projects
  - VTN Usability Enhancements
    - Improved user interface to simplify actions associated with common utility use cases
  - CIM Interface for VTN
    - Connecting the IRC's WDRCP (CIM-based wholesale DR messages) to OpenADR
  - CEA-2045
    - Modular communication controllers using OpenADR
- EPRI ICT Innovators Forum
  - Improved alignment between utility needs and wants and solution provider offerings and roadmaps
  - New project just being launched now

Together…Shaping the Future of Electricity

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Q&A

- Recording and slides from this presentation will be available at www.openadr.org.
- For more information on this presentation, contact Walt Johnson at hwjohnson@epri.com.
- The OpenADR Webinar Series will continue throughout 2015. More information on future webinar topics can be found on www.openadr.org.

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Thank You!

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