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Adaptive Middleware for the Smart Grid

Carl A. Gunter
University of Illinois

Goals and Challenges for Power Grids

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- Goal: deliver power reliably and efficiently
- Strategy: send electricity along a sequence of links of varying voltage
  - Transmission and distribution substations
- Challenge: supply must continuously match demand since electric power cannot be stored
- Strategy: provision the system with flexibility and balance it dynamically
  - Successful, but with limits in reliability and efficiency

What is the “Smart Grid”?

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Strategy

Push the power grid realization in two complementary directions

- Exercise greater computer monitoring and control over digital networks
- Rely more on Distributed Energy Resources (DERs)
  - Demand Response (DR)
  - Distributed Generation (DG)
  - Storage

Sample Benefits

- Use DR to provide support for battery vehicles with no new provisioning
- Increase situational awareness through an extensive sensor grid

Key Power Grid Environments

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- Regional Transmission Operators (RTOs)
  - with digital energy markets
- Control Centers
  - with Supervisory Control and Data Acquisition (SCADA)
- Substations
  - with automation based on LAN busses
- Advanced Meter Infrastructure (AMI)
  - with bidirectional communication on wireless links

Sample Objectives for Adaptive Middleware in the Smart Grid

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- Improve the abstraction and interoperability of SCADA communication with Intelligent Electronic Devices (IEDs) in substations. Adapt to new IEDs and integration opportunities.
- Improve the security configuration of substations to manage secure group multicast to assure low latency operations. Adapt to latency requirements of new types of messages.
- Improve head end integration and security.

Focus

Head End Integration

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- "Head end" is an old term from Automated Meter Reading (AMR)
- It is the point where the data is taken into the utility from a series of networks
  - Home Area Network (HAN) to the meter
  - Field Area Network (FAN) to the access point
  - Backhaul Network to the head end
- AMI is moving to a new level with more interesting and integrated apps

Challenge

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- Smart grid applications are diversifying the potential uses of grid sensors and controls
- New types of control in new head ends
  - Example: real time aggregator for battery vehicles
- Integration of functions offers new opportunities
  - Example: outage management exploiting both distribution substation and AMI data
- How can we support this diversification in a cohesive framework?

Addressing Security and Integration with Adaptive M/W

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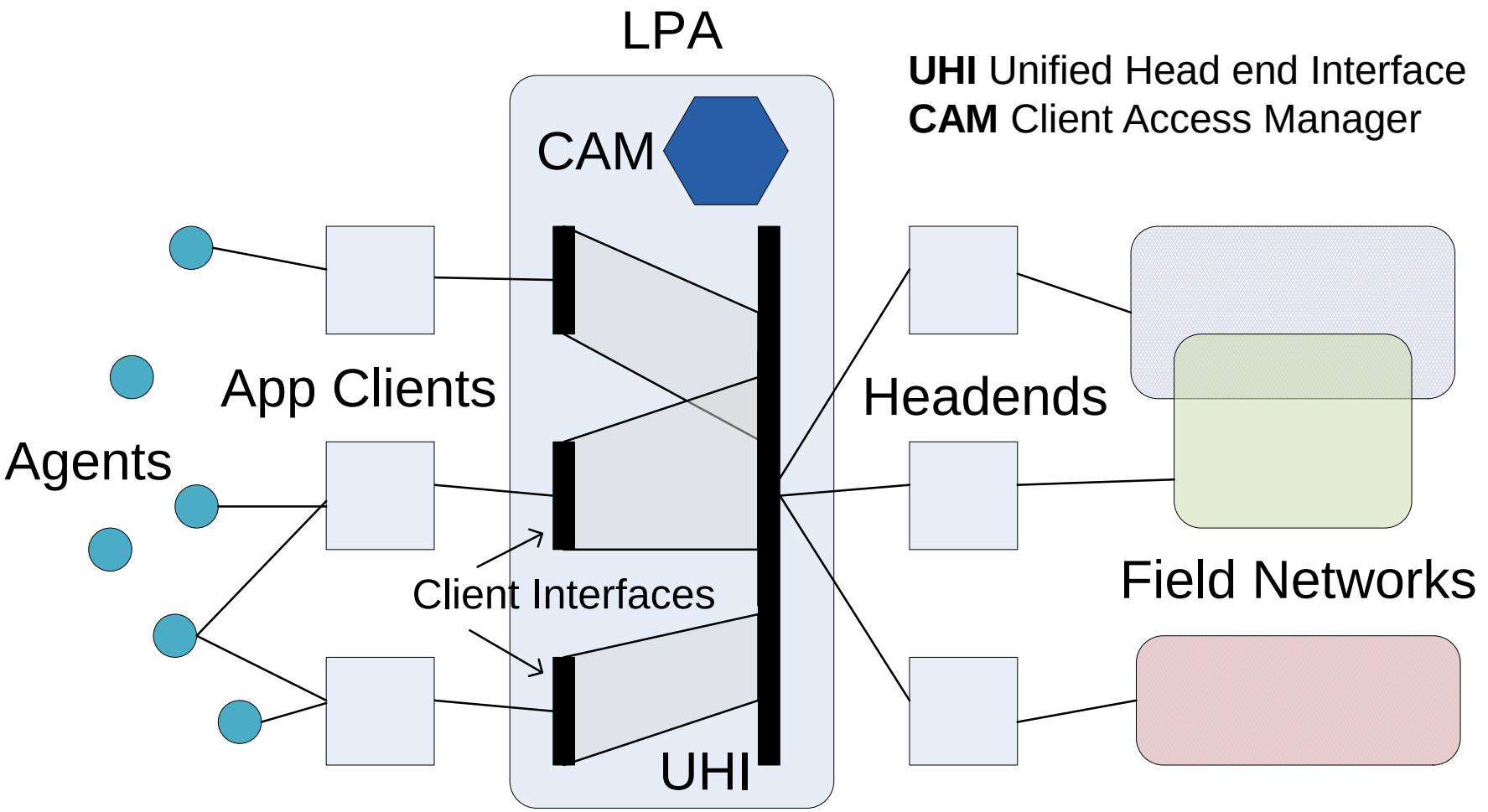
- Architectural concept: provide M/W that unifies diverse head end interfaces
- Enable the creation of adapters that can support limits on least privilege for applications that work through the unified interface
- Dual achievement possible
  - Full support for integrated applications
  - Limits on risk from abuse of a broad interface

Least Privilege Architecture (LPA)



Conclusions and Questions

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- Adaptive middleware will have an important role to play in the Smart Grid
- It will contribute abstraction, interoperation, and adaptation for performance and security
- What are the essential new features of adaptive M/W in this emerging context?
- What research is needed short term (to impact current deployments) and long term (rethinking digital networking for a key new context)?