Field Area Networks (FANs)

CS 687
University of Kentucky
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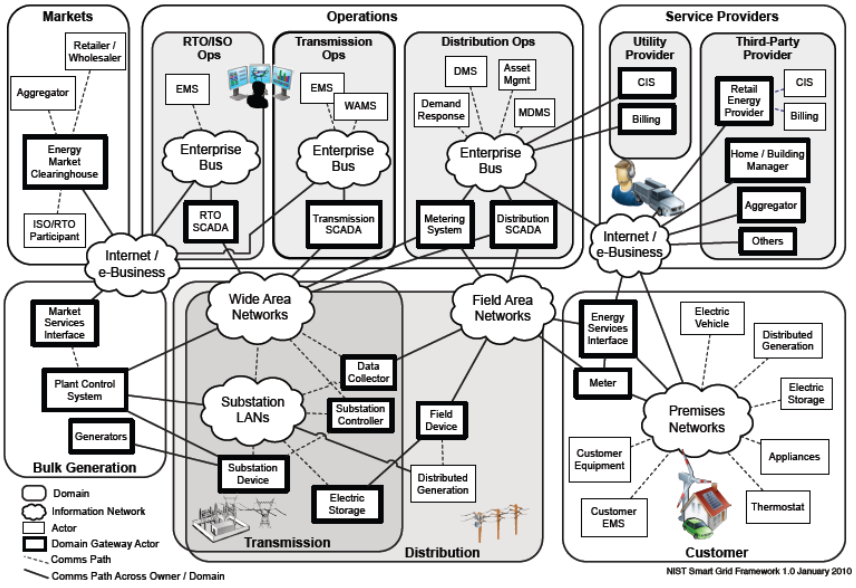
Acknowledgment: These slides have used resources (presentations, documents, pictures) available on the web. Most of the slides are from the presentation by Craig Rodine and Tim Godfrey from Electric Power Research Institute (EPRI).

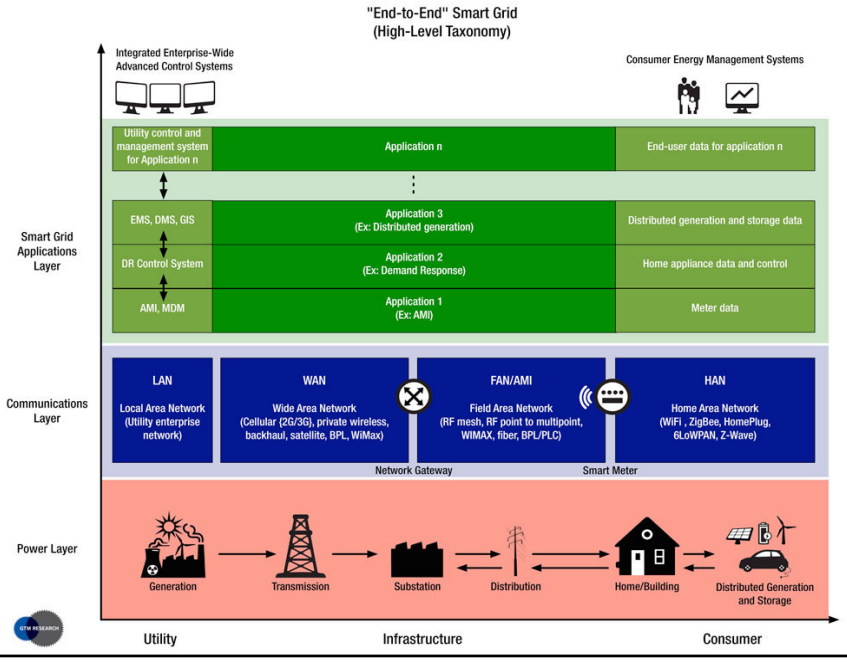
Outline

- What is FAN?
- FAN applications
- FAN examples
- Power Line Communications

NIST Framework



End-to-End Smart Grid (High-Level Taxonomy)



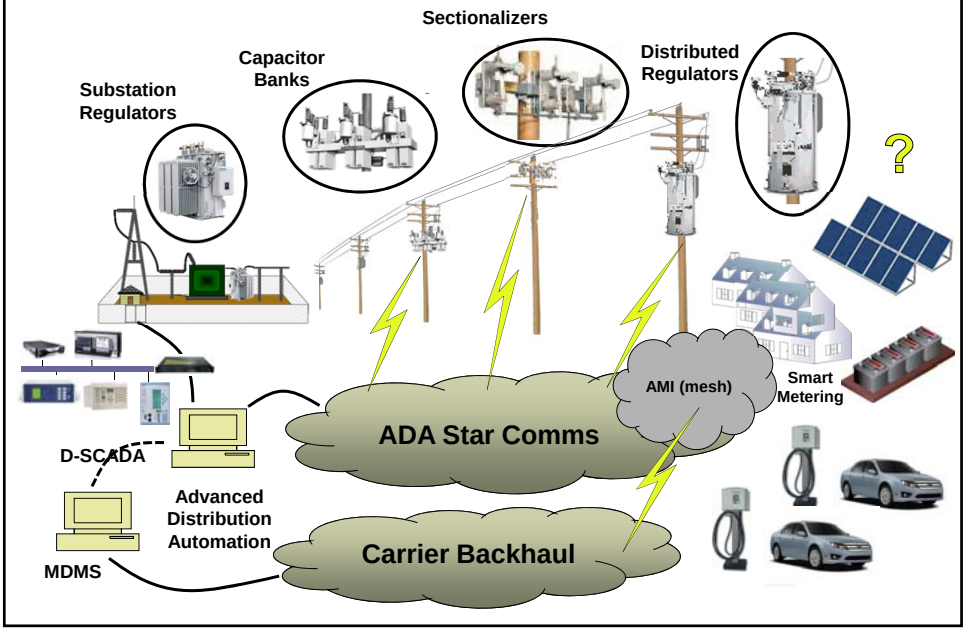
Field Area Network – what and why?

- FAN – why a new term?
  - Established labels for network scale and scope don't meet the need
  - Utility industry can support new concepts (i.e. HAN)
- FAN is an amalgam and extension of WAN/MAN/LAN
  - Covers entire utility service area
    - Dense urban, suburban, rural
  - Engineered to support utility-specific applications and requirements
    - Advanced Distribution Automation, integrated Distributed Energy Resources, Demand Response, Electric Vehicle Charging

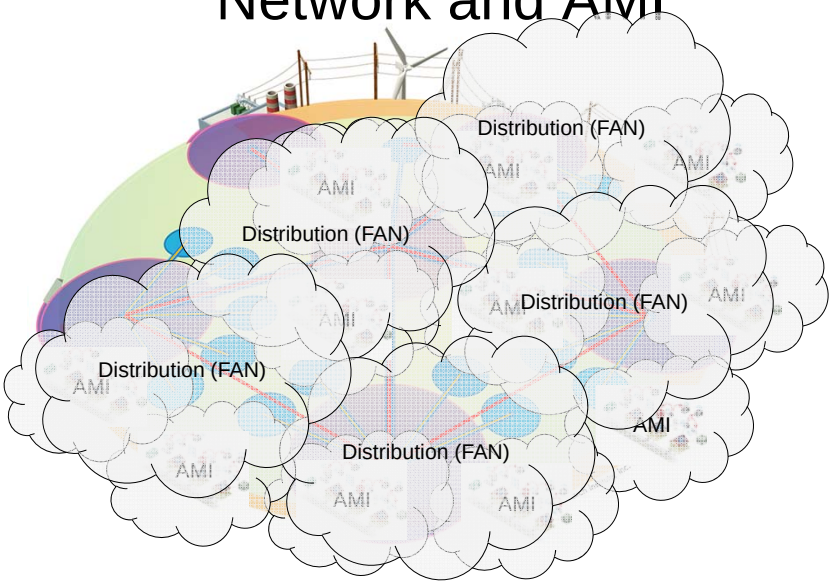
Smart Grid

- "First Wave" (2007 – 2010 in North America, Europe)
  - Introduced Smart Meters, AMI, some Distributed Energy Resources (DERs, e.g. PV) at network edge
  - Promise of residential demand response, plug-in vehicle integration (but still in trials)
  - No integration with utility operations (in particular, distribution SCADA)
- "Second Wave" (begins 2011, worldwide)
  - Extensible infrastructure for *critical* utility operations
  - Supporting high level of DER penetration and systems integration
  - Communications focus: high-reliability Field Area Network, M2M applications, more hierarchical/distributed control

Present day D-SCADA and AMI networks



Distribution (Field Area) Network and AMI



Field Area Network Applications

- Field Area Network - FAN
  - Ubiquitous, broadband wireless resource
  - Meets stringent utility requirements for reliability, resilience
  - Capacity sufficient to support *all* current and anticipated applications
- Integration of legacy and "First Wave" applications ..
  - Distribution Management Systems – DMS (SCADA)
  - Advanced Metering Infrastructure, Demand Response, Distributed Energy Resources (incl. PHEV charging)
- .. with "Second Wave" Smart Grid applications
  - Advanced Distribution Automation: Fast fault location, recovery, and automated sectionalization; Conservation Voltage Regulation; Volt/Var control; Power Quality controls; etc.
  - Fine grained load profiling and control of Distributed Energy Resources, including roaming DERs (EV charging)
  - Integrated field operations and support, mobile data, voice (VoIP)

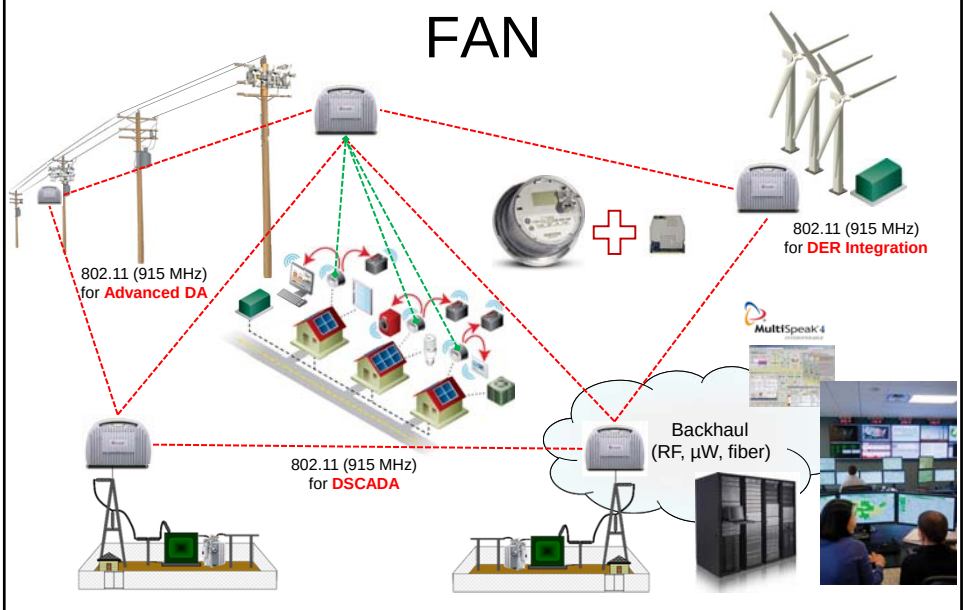
FAN applications for Smart Grid (Support)

- Field Operations Support
  - Mobile voice
    - LMR or cellular replacement
    - Longer term
  - Mobile data
    - Maps, manuals, reference documents
  - Consolidation of multiple networks on one infrastructure
- Transportable Base or Relay station
  - Create "hot spot" in high activity zones
  - Supplement coverage in difficult areas (vaults, etc)

Examples of FANs

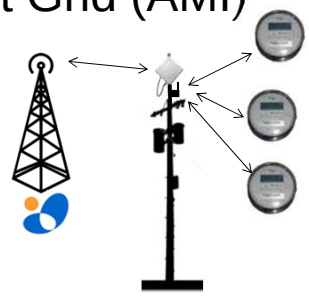
- IEEE 802.11
- IEEE 802.15.4
- WiMAX (IEEE 802.16) and GRIDMAN
- Power Line Communications (PLC and BPL)

Industrial Wi-Fi® (unlicensed) FAN

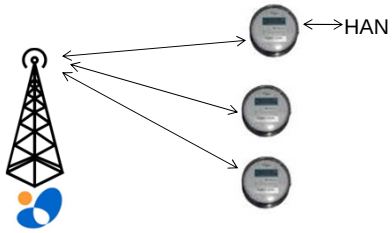


FAN applications for Smart Grid (AMI)

- AMI backhaul
  - AMI links to collector
    - Using 802.15.4g or other
  - Collector contains WiMAX device



- Direct AMI / HAN
  - Smart Meter contains WiMAX device
  - Possible Gateway to HAN



802.16n - GRIDMAN Purpose and Scope

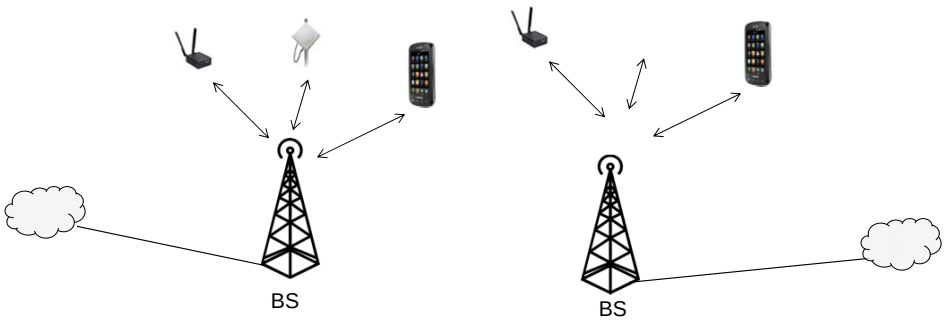
- GRIDMAN – “Greater Reliability in Disrupted Metropolitan Networks”
  - Improving metropolitan area and field area wireless network reliability and robustness by orders of magnitude
- Applications / Stakeholders
  - Utilities: Smart Grid, Distribution Automation
  - Public Safety
  - Disaster Relief
  - Government applications
  - Critical Infrastructure

Power Line Communications
on separate slides

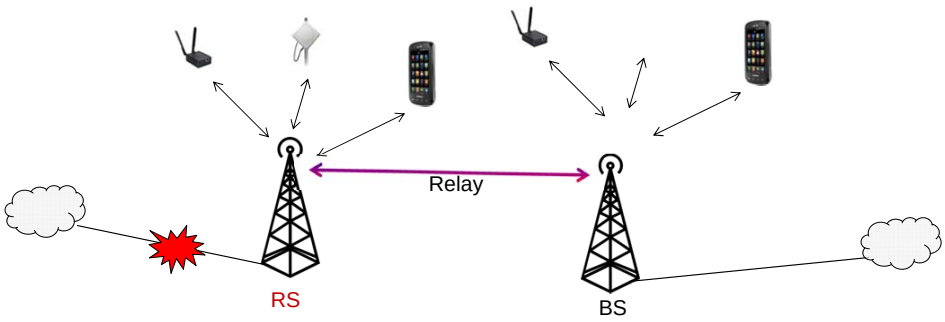
GRIDMAN Requirements Overview

- Enable deployment of networks with “Four 9’s” of reliability
- Immunity to single point of failure
  - Base stations can become relays if backhaul is down
  - Mobile stations can become relays to help other mobiles communicate with a base station
  - Mobile stations can form “ad-hoc” networks if all base stations are down
  - Mobile stations can function as base stations (with limited capabilities) in case of primary base station failure

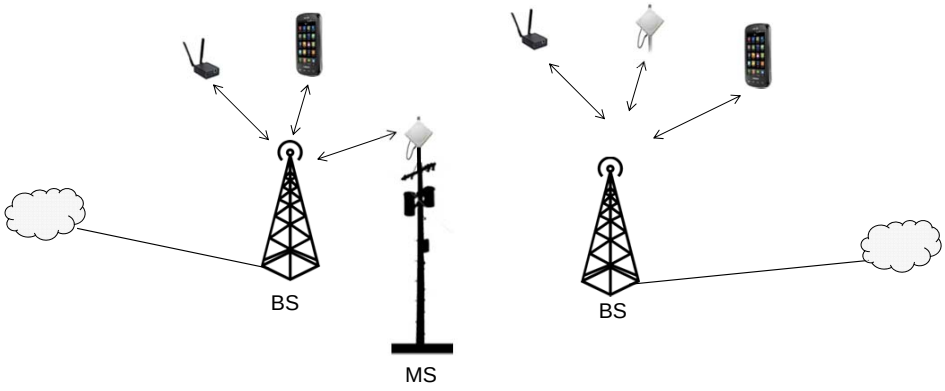
BS becomes RS



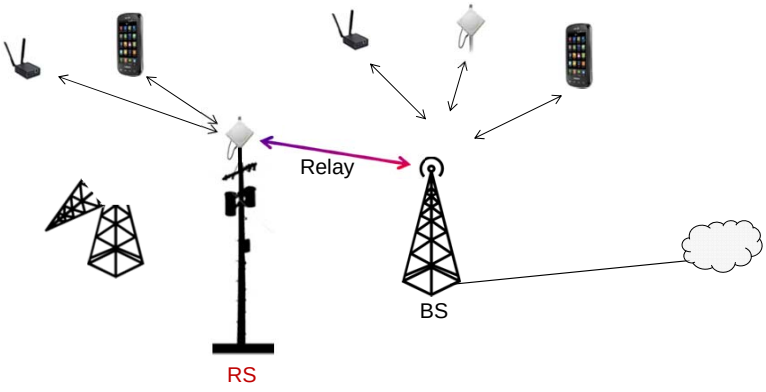
BS becomes RS



MS becomes RS



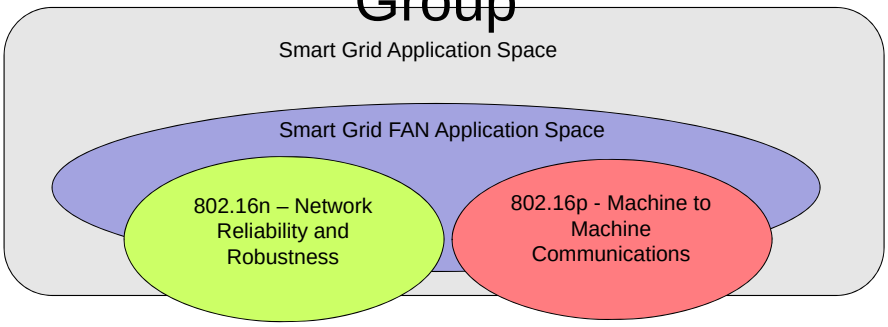
MS becomes RS



GRIDMAN Requirements Overview

- Dynamic Network Architecture
  - Devices can change roles as required to deal with failure and disruption
  - Multiple path routing and neighbor discovery
  - Combination roles
    - For example a station can serve as a relay to other stations while also sending and receiving its own data.
  - Base stations and relay stations can form “chains” if needed to reach infrastructure (multi-hop)
  - Base stations and relay stations may become mobile

GRIDMAN and M2M Task Group



- 802.16n (GRIDMAN) – Reliability and robustness
- 802.16p (M2M) – Machine to Machine enhancements
- Each task group addresses unique Smart Grid requirements