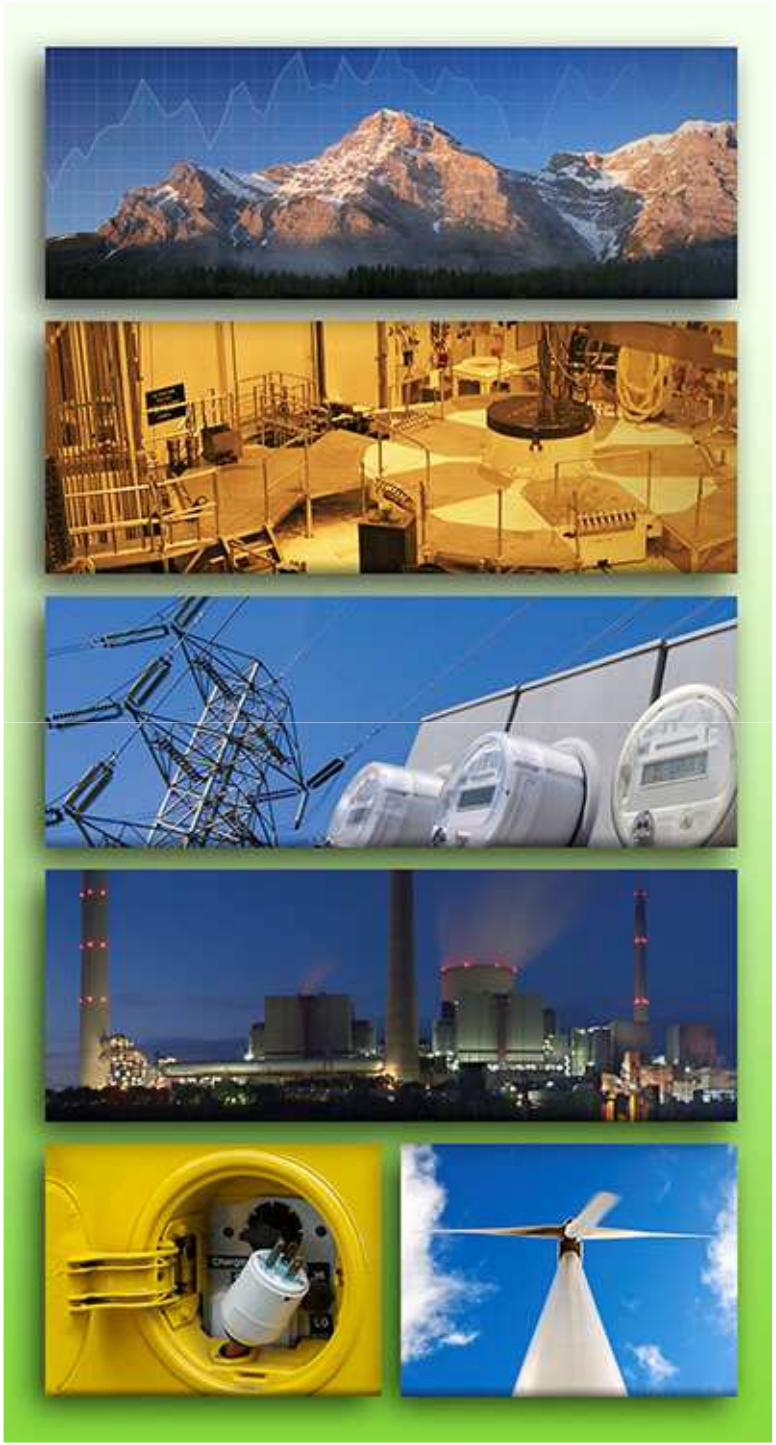


EPRI ELECTRIC POWER RESEARCH INSTITUTE

The Field Area Network – A WiMAX application for Smart Grid

Tim Godfrey

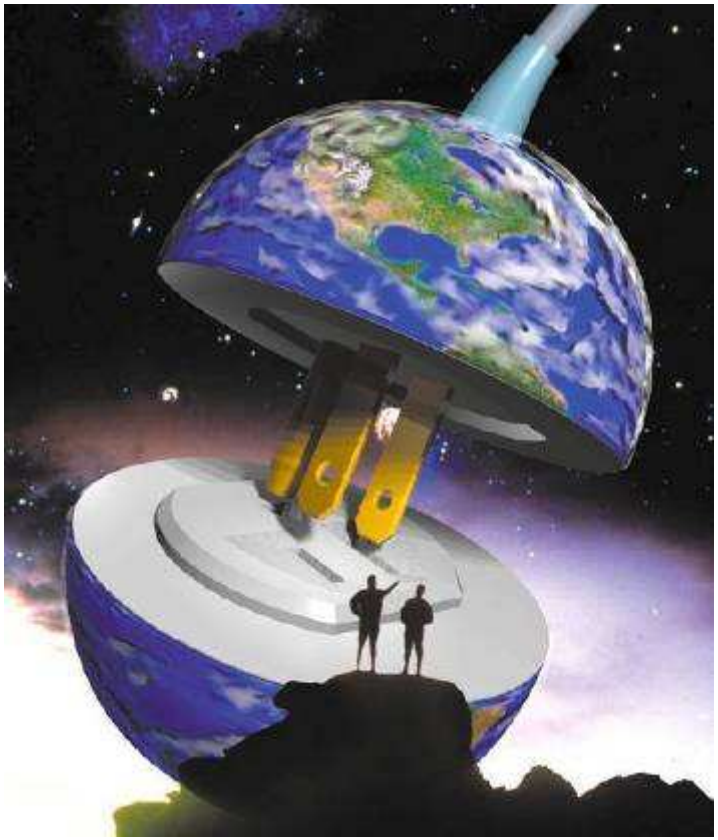
2011 Taipei WiMAX Summit
10 January 2011

Agenda

- Brief introduction to EPRI
- WiMAX Applications for Smart Grid
- 802.16n GRIDMAN application scenarios
- GRIDMAN requirements

Electric Power Research Institute (EPRI)

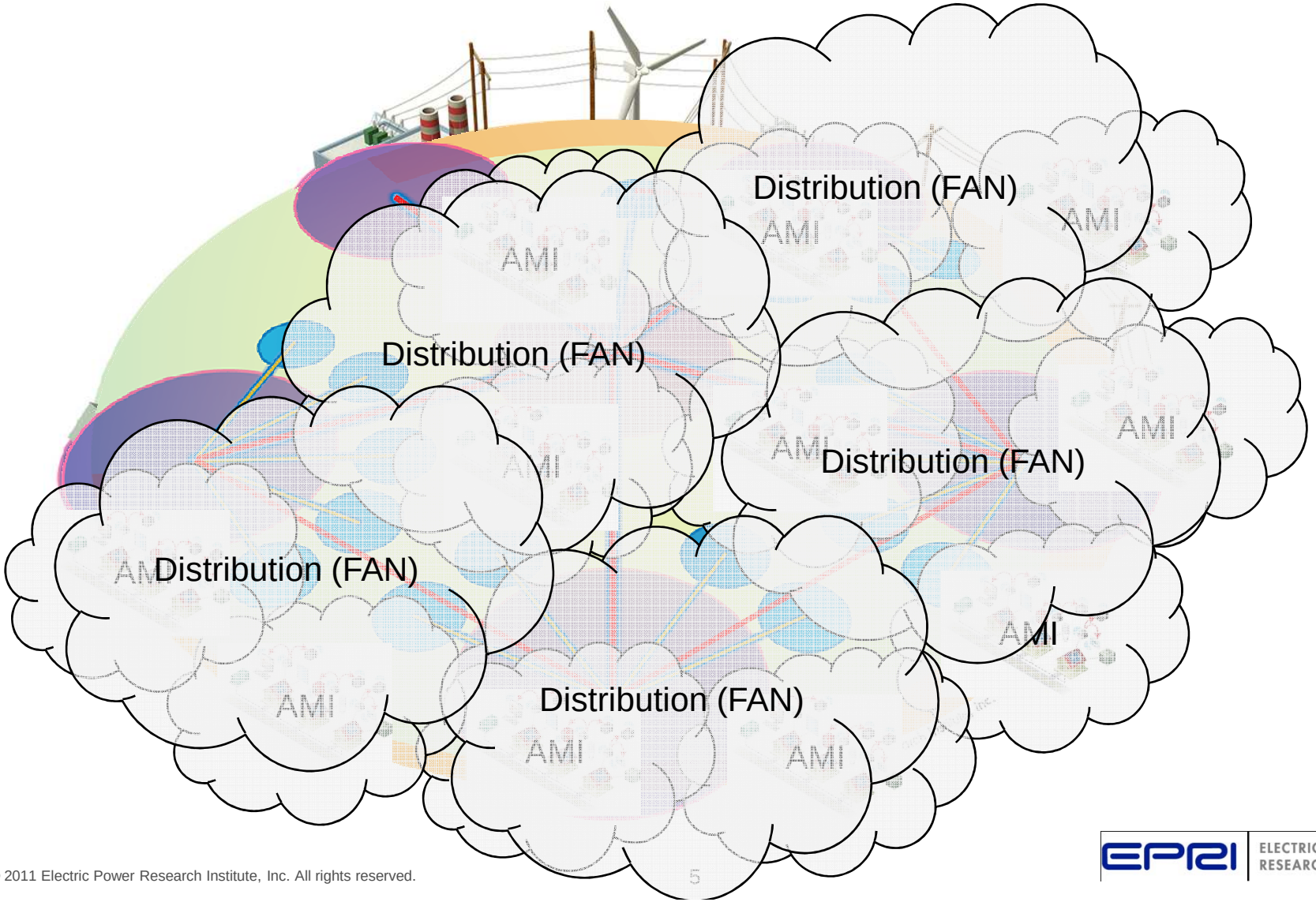
- Founded by and for the electricity industry in 1973 as an Independent, nonprofit center for public interest energy and environmental research
  - EPRI utility members represent >90% of electricity generated in the USA
- Collaborative resource for the electricity sector
  - ~$350M annual R&D funding, ~18% international members, participants in more than 40 countries
  - 470 engineers and scientist, offices in Palo Alto, CA, Charlotte, NC & Knoxville, TN. Labs in Charlotte, Knoxville and Lenox, MA
- Four major R&D portfolios: Nuclear, Generation, Environment, and Power Delivery & Utilization



Smart Grid

- "First Wave" (2007 – 2010)
  - 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)
  - 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

Distribution (Field Area) Network and AMI

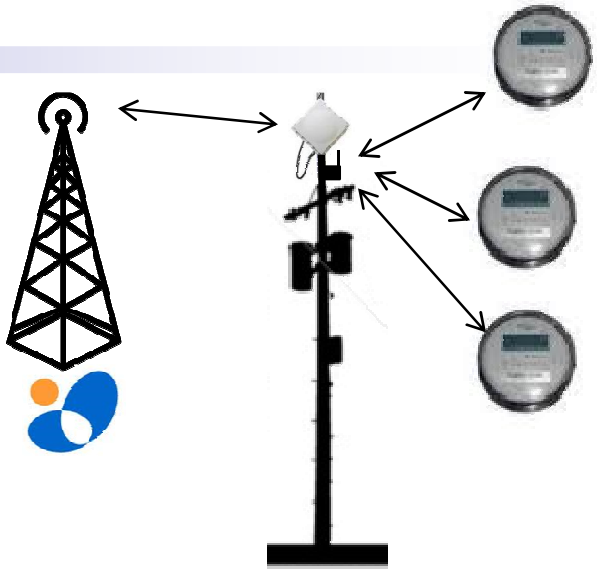


Field Area Network Overview

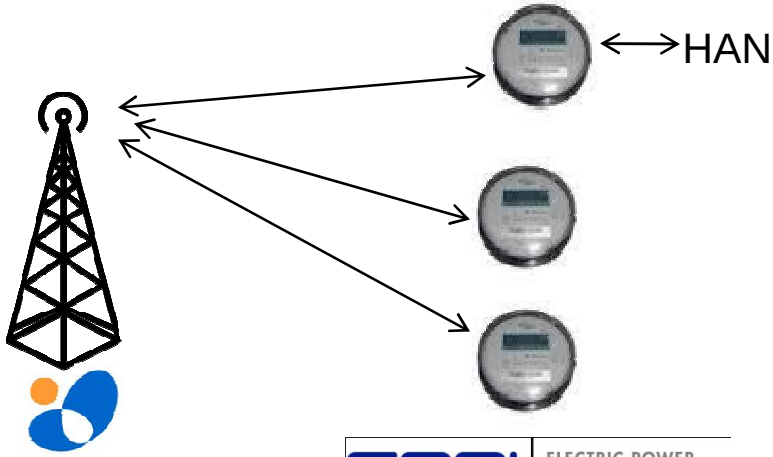
- Field Area Network - FAN
  - Ubiquitous, broadband wireless resource
  - Meets stringent utility requirements for reliability, resilience
  - Designed to support *all* current and anticipated applications
- Integration of legacy and “First Wave” applications ..
  - Distribution Management Systems – 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)

WiMAX 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



EPRI ELECTRIC POWER RESEARCH INSTITUTE

WiMAX 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)

Goals for WiMAX to address Smart Grid

- Network Infrastructure
  - Increase reliability to meet utility requirements
  - Long service life in the field, upgradeable

- Devices
  - Drive down WiMAX terminal cost with volume
  - Meet AMI price point compared to 802.15.4g
  - Enable broad market for WiMAX-based Smart Grid
  - New classes of devices implementing 802.16n and 16p

Disclaimer…

"At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE."

IEEE-SA Standards Board Operation Manual (subclause 5.9.3)

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

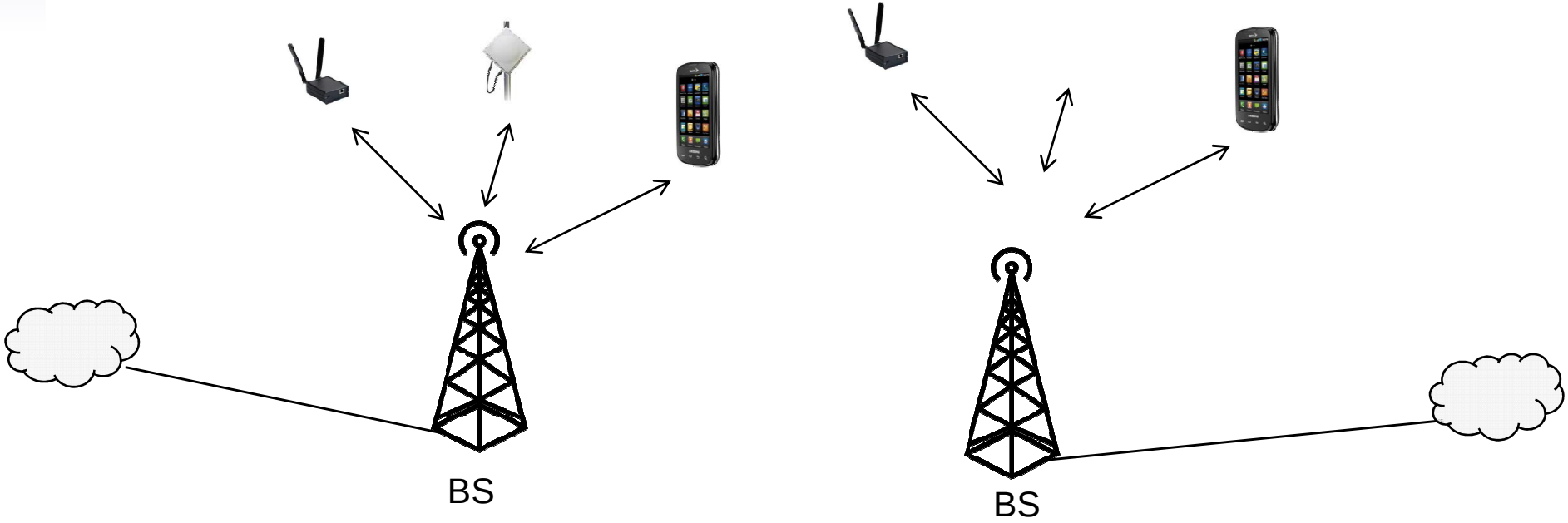
- Applications / Stakeholders
  - Utilities: Smart Grid, Distribution Automation
  - Public Safety
  - Disaster Relief
  - Government applications
  - Critical Infrastructure

GRIDMAN Requirements Overview

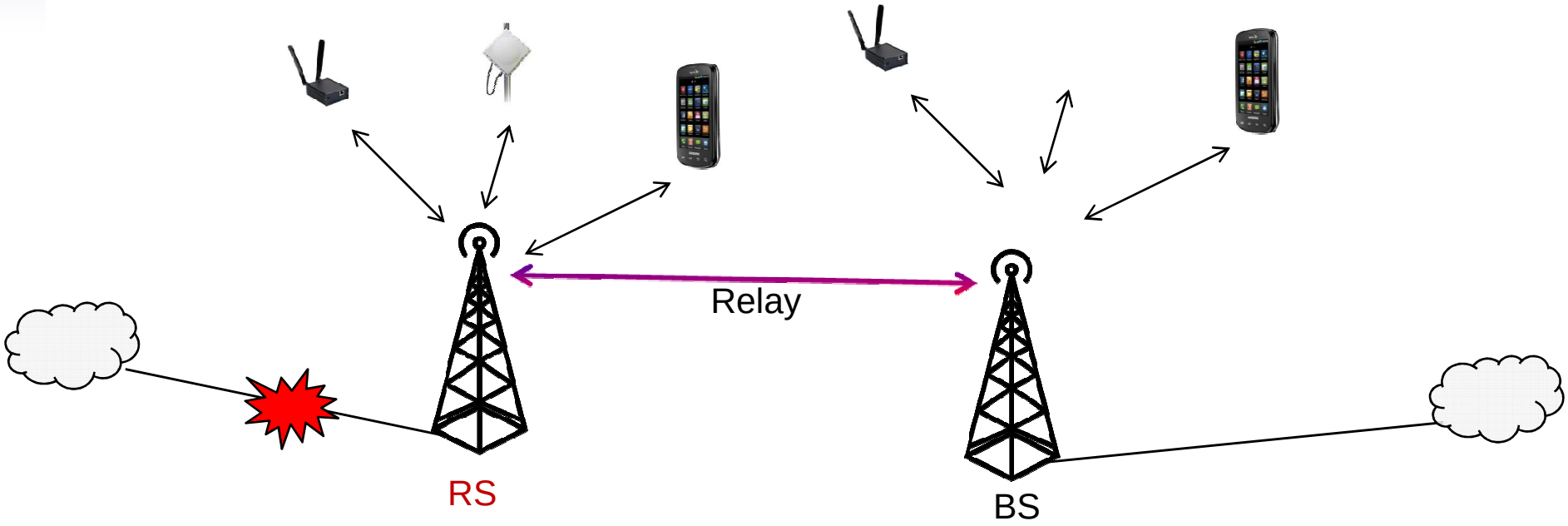
- Enable deployment of networks with “Four 9’s” of reliability

- 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 bases station failure

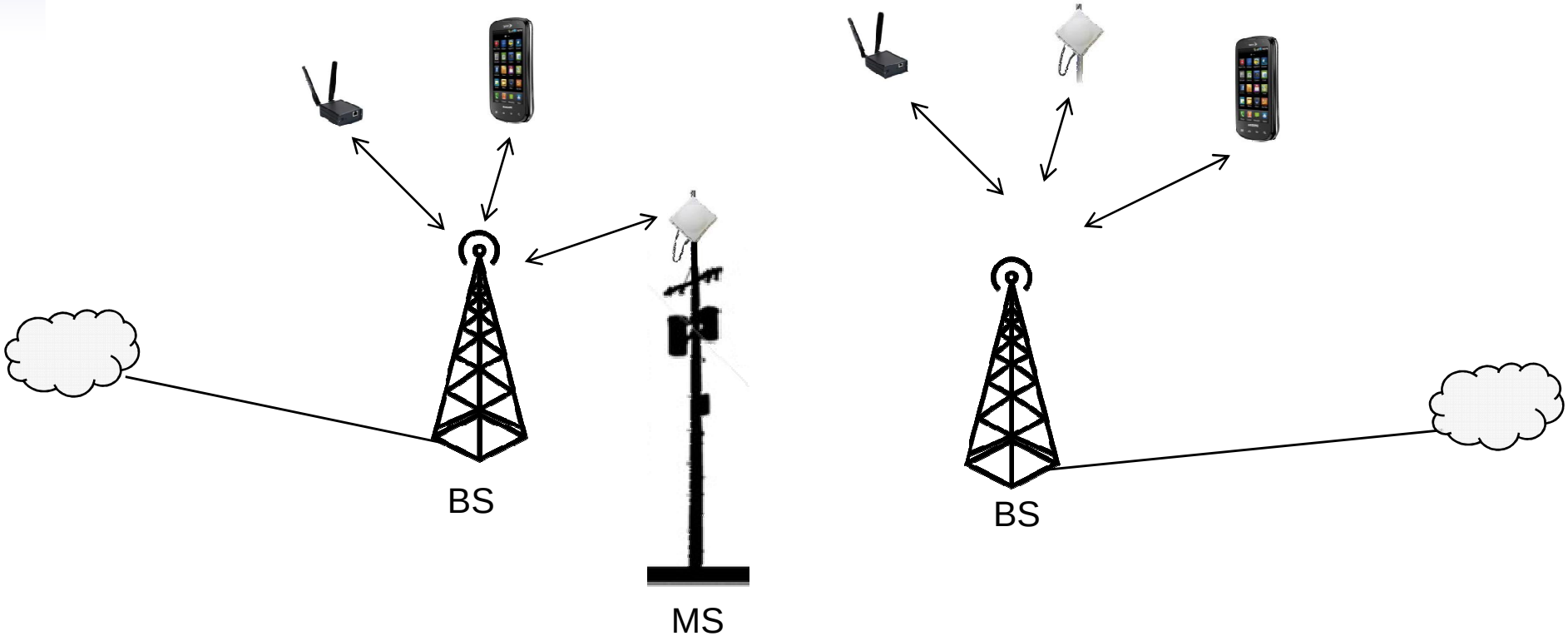
BS becomes RS



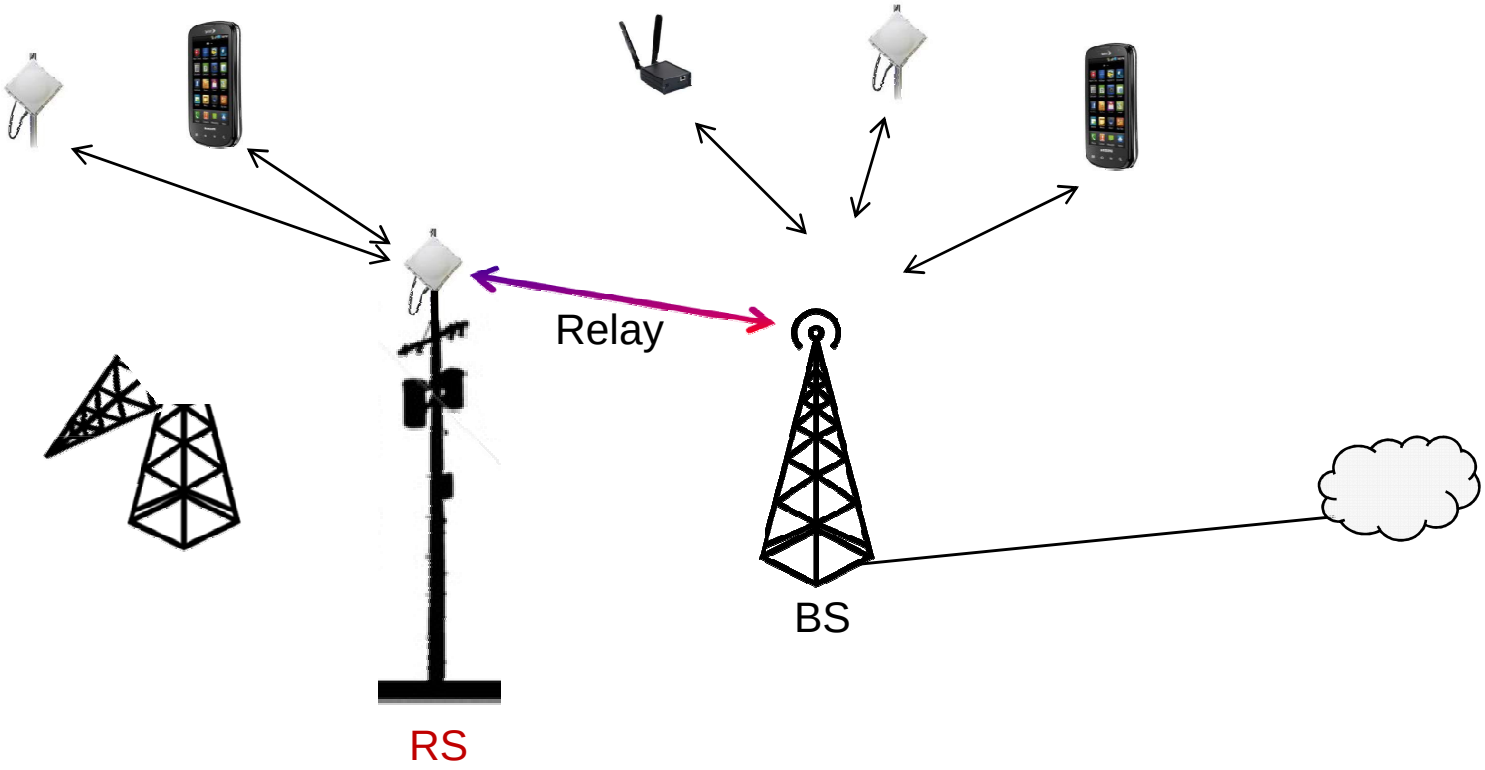
BS becomes RS



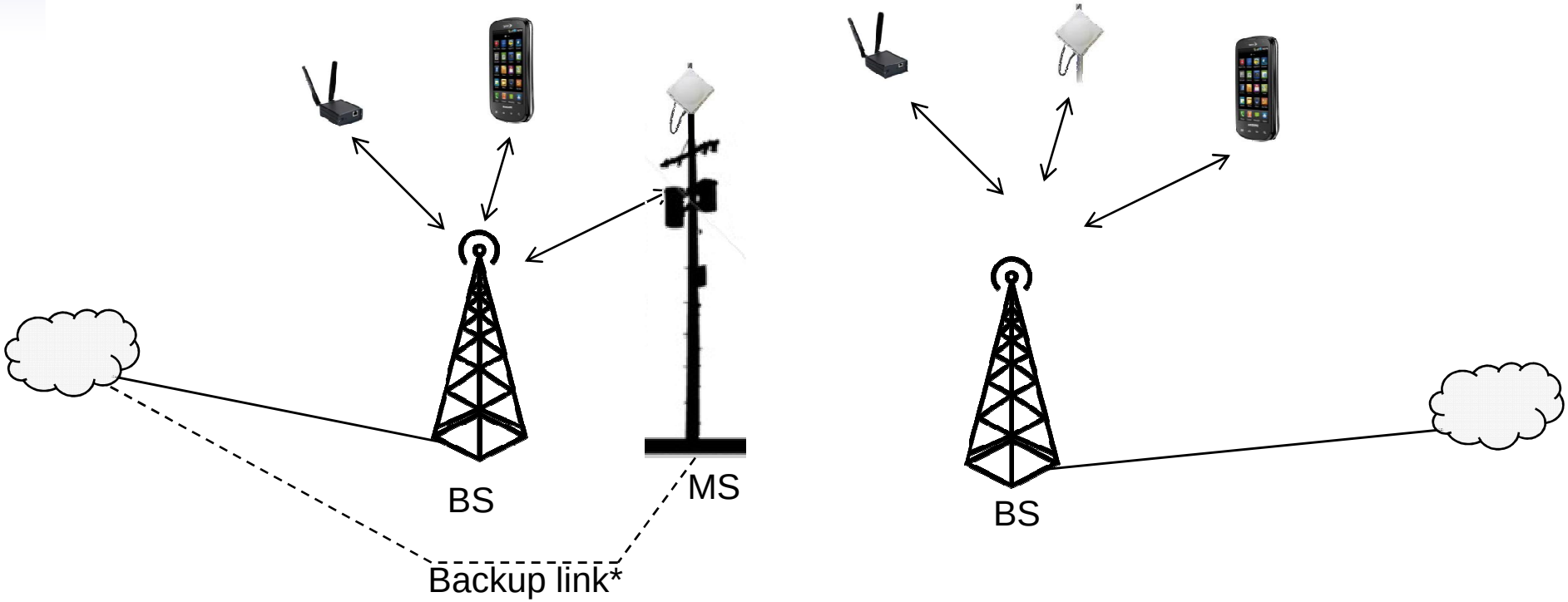
MS becomes RS



MS becomes RS

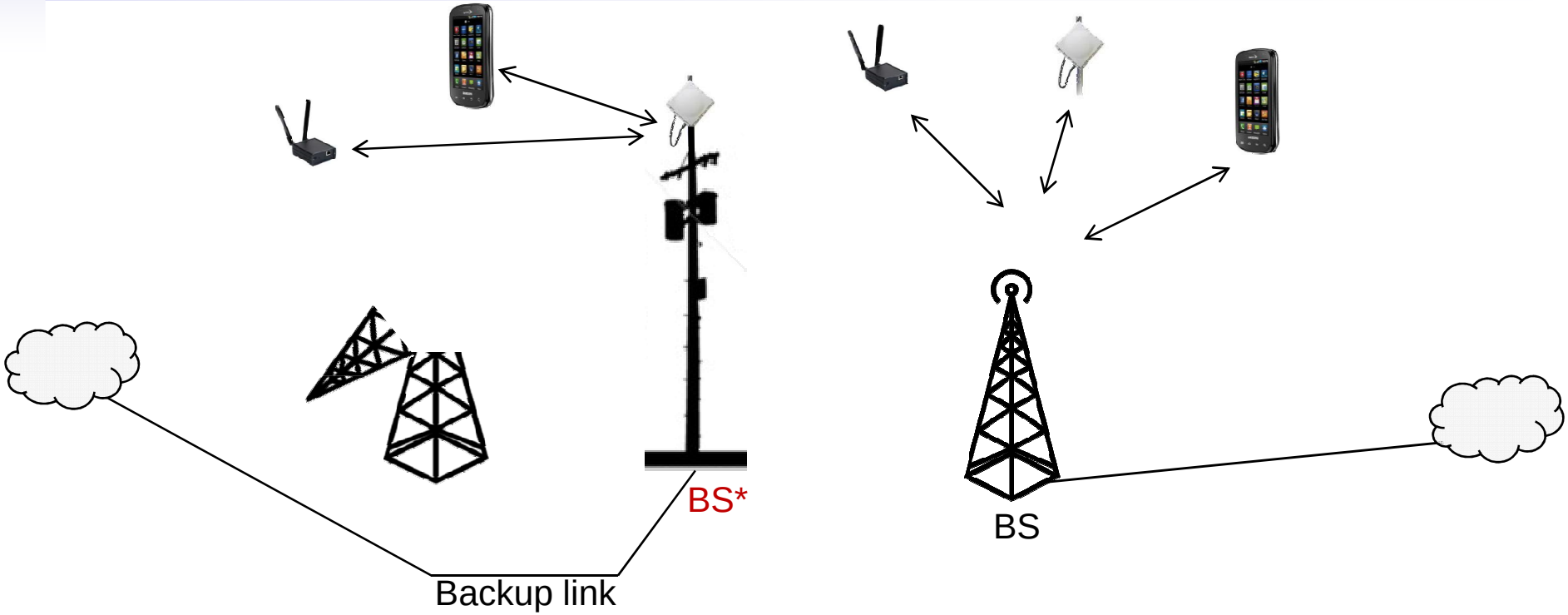


MS becomes BS



* Certain critical devices will always require backup communication

MS becomes BS



* Use MS to BS transition to extend backup link to other devices

GRIDMAN Requirements Overview

- Dynamic Network Architecture
  - Devices can change roles as required to deal with failure and disruption
  - Multiple path routing and neighbor discovery is supported
  - Combination roles are supported
    - 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 Requirements Overview

- Multicast Group Support
  - Large group multicast support
  - Emergency voice calling and enhanced VoIP services

- Flexible RF
  - Licensed, unlicensed, and “lightly” licensed bands
  - All radio frequencies where 802.16 operates
  - Bandwidths of the WirelessMAN-OFDMA or WirelessMAN-Advanced Air Interfaces.
  - Single or multiple RF carriers.
  - Support of TDD and FDD.

GRIDMAN and M2M Task Group Timetable

- 802.16n (GRIDMAN) and 802.16p (M2M) each address unique Smart Grid requirements
- 802.16n was formed slightly ahead of 802.16p
- Both Task Groups are targeting drafts in late 2011, and final approval in late 2012

Conclusion

- WiMAX can support the Field Area Network for Smart Grid applications
  - 802.16 is extending and improving performance characteristics relevant to the Smart Grid
- New EPRI Field Area Network Initiative
  - Validate utility infrastructure reliability and resiliance requirements
  - ‘Pre-Demo’ funding to establish industry-wide prototyping and demonstration of FAN
  - Infrastructure, silicon, and equipment vendors are welcome to participate
  - Program contact is Craig Rodine – crodine@epri.com