Communication Diversity Architecture for Smart Meter Networks

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Communication Diversity Architecture for Smart Meter Networks

Smart Meter Network

Communication Solution

Picture courtesy DS2
Distribution System Operator (DSO¹)

A new role

Note 1: Also called DNO or DGO

Deregulated market in the EU: Responsibility of DSO

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Dealing With The Situation
The Dutch Case

Circumstances
• Legislation is pending
  – Trial period (2011-2012)
  – Large scale roll-out (start 2012, 80% in 2020)
  – Smart Meter not mandatory: consumers can refuse
• Data Protection Authority
  – Metering is privacy sensitive information
• Media and Public Opinion
  – Sceptical on Security & Privacy matters
  – Benefits unclear

Consequences for DSO’s
• Uncertainty in many aspects
  – Required functionality of system and meters
  – Number of meters and related timing of roll-out
  – Technological development (what is smart?)
  – TCO and business case
Telecom for Smart Meter Networks (1/2)
A complicated matter

Smart Metering is all about communication
• Remote reading and control
• Interaction with customers, providing additional services

Smart Metering is complicated for telecom
• Smart Metering environment is inconsistent, but consistently harsh
• No communication technology provides 100% coverage
• Life cycle of (smart) meters and telecom are incompatible

Telecom technology for Smart Metering is in development
• Examples:
  – Power Line Communication: 2nd gen S-FSK → 3rd gen OFDM
  – Mobile Communication: GSM → UMTS → LTE
  – Fixed Line: Cable / ADSL → optical Fiber
  – Internet Technology: IPv4 → IPv6
• Piggyback on the Internet of Things!
Telecom for Smart Meter Networks (2/2)
Examples

Mobile Communication
• GSM almost 100% coverage
• Lifetime? Cost?

PLC (power line communication)
• Slow development of technology
• Primitive architecture
• Capacity? Robustness?
Communication Diversity Architecture
A decent proposal

Flexible
- Mix of multiple technologies
- Irregular, scattered roll-out

Reliable & Secure
- Redundant communication paths
- No intermediate storage

Cost efficient
- Investment at installation

Future proof
- Add new technologies
- Add capacity locally
- Exchange 1 on 10

Smart Meter Management System
Central System
WAN (e.g. GPRS)

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Communication Diversity Architecture
For many reasons

Field experience
This architecture is based on the Eandis multiple gateway concept:
• WAN: Cable, ADSL
• LAN: PLC with data concentrator as gateway; includes modified PHY and LLC
Eandis is running a trial in Belgium with 4k meters (expansion in 2011 to 40k).

Features of Communication Diversity Architecture
• Fault-tolerant architecture, ensuring multiple routes that allows the network to continue operation in the event a node fails
• Self-healing configuration by employing mesh capabilities at various layers and redundant operation of nodes
• Flexible and scalable architecture, ready for secure communication through encryption and authentication of data without the need for intermediate storage
Communication Diversity Architecture
The Elements

WAN technologies
• Mobile Communication: GSM (cheap), LTE (fast)
• Fixed Line (when accessible): Cable, ADSL, optical Fiber

LAN technologies
• PLC: next generation PHY and data link layer, e.g. ERDF/Maxim/Sagem PLC G3 OFDM
• Meshed RF, e.g. ZigBee based protocols with IP support (IPSO)

Gateway
• Transparent: basic protocol translation, no storage
• Low cost: adaptation based on open, international standards

Addressing and Routing
• IPv6: needed to connect to the Internet of Things
• 6LoWPAN: IETF draft with IPv6 for resource constrained networks
Communication Diversity Architecture
The big picture

- **Application**
  - **IPv6 stack**
  - **WAN IPv6 basis**
  - **IPv6 stack**
  - **6LoWPAN**
  - **LAN e.g. PLC or Meshed RF**
  - **6LoWPAN**
  - **IPv6 stack**
  - **Application**

- **E.g. Fiber IPv6 SSL/TLS**
- **E.g. LTE IPv6 VPN tunnel**
- **E.g. DSL/cable IPv6 IPsec**
- **E.g. GPRS IPv4 VPN tunnel**

- **GW**
- **CN**
- **MN**

- **Smart Meter Management System**

- **IPv6 network**

- **Multiple external interfaces**

- **GW as L3 router**

- **L3 routing**

- **E.g. Meshed RF network**

- **E.g. PLC network**

- **L2 routing including hopping**

CN = Central Node
GW = Gateway
MN = Meter Node

MNs shall be able to migrate from one GW to another GW

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Open Standards
A wise thing to do

Open Standard
• Specification that is publically available with associated rights
• Not always for free: "reasonable and non-discriminatory" royalty fees
  – If EU standard (CEN): free of fee
• Internationally recognized bodies
  – IETF, ISO, IEC, ITU-T, ETSI
• Additionally: approval by formalized committees
  – Compliancy test by User Association
  – Guarantees interoperability

Benefits
• Multi-vendor ecosystem
  – Lower cost by economy of scale and competition
• Large community
  – Thoroughly tested in variety of applications and environments
  – Abundance of tooling available
Message to ETSI M2M
Spreading the news

Features of Communication Diversity Architecture
• Fault-tolerant, Self-healing → multiple routes for nodes, mesh capabilities at various layers
• Flexible and scalable → extensions at every node
• Secure communication → building on existing knowledge, include privacy

Communication Diversity for the Internet of Things
• Fits very well in current international developments
• Reference architecture based on IPv6
  – IETF 6LoWPAN
  – PLC G3 OFDM
  – DLMS/COSEM

What can ETSI M2M do?
• Specifications for overall Smart Meter Network with Communication Diversity → research needed on functionality and performance
• Gateway is central device in this concept → determine functional specification for various communication technologies
Backup Slides

Communication Diversity Architecture
Requirements for Future Proof Design

- Piggyback on the **Internet of Things** based on **IPv6**
  - Security → end-to-end security
  - QoS and management (SNMP) build in
  - Adaptation for resource-limited networks (6LoWPAN), see G3 PLC
- Universal routing to achieve **Communication Diversity**
  - Adapt to dynamic topology changes
  - Avoid data aggregation (DC’s), use gateways instead
  - Inherent routing with IPv6
- Leverage **Medium Access** layer
  - Include roaming, i.e. multiple master (node can change route)
  - Include random access (node can push data), multicast, broadcast
  - Optimize coordination (Slotted Aloha max. throughput is 37%)
- Future compatible **Physical** layer
  - Future updates of PLC shall be backwards compatible → coordination
  - Use open, non-proprietary standards → cooperation
Overview of the Electricity Net
WAN Technologies
Wide Area Network

GSM
- Revival of GSM/GPRS: Operators investing in M2M
- Sufficient throughput: average ~ 50 kbps, max. 115 kbps
- Good indoor penetration at low frequency band (900 MHz)

LTE
- Superseding UMTS & HSPDA
- Future proof: High throughput in uplink (~20 Mbps at 5 MHz); short delay (< 5ms)
- Flexible in frequency band (e.g. 900 MHz or lower for indoor penetration and range)

Cable, (A)DSL
- Broadband access, usage country specific
- However, access not next to meter!

Optical Fiber
- Broadband access with many services
- Piggyback on roll-out with specific service

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Local area networks (LAN) or neighbourhood networks (NAN) for smart meters typically use access technologies that are resource-constrained and must operate unattended for multiyear lifetimes.

**Meshed RF**
- Popular in the USA (PLC, mobile difficult)
- Popular for sensor-networks, based on ZigBee
- ZigBee with Smart Energy 2.0 under development
  - End-to-end IP with IPv6 and 6LoWPAN
  - Independent from PHY/MAC

**PLC**
- Current solutions: primitive architecture, tree topology
- Large scale pilots in Europe → development of new standards
- PLC G3 OFDM specification provides many features:
  - End-to-end IP with IPv6 and 6LoWPAN
  - OFDM PHY, with significant performance improvement
  - Introduced as free and open standard in Open Meter
Gateway
Connecting LAN with WAN

Transparent
• Basic protocol translation
  – End-to-end IPv6 solution
  – L2 or L3 routing:
• No storage, otherwise:
  – Security issue
  – Additional hardware

Low cost
• Open, international standards: known and tested
• Path search for lowest cost on WAN interfaces
• Switch between states
  – Gateway
  – L3 router
  – L2 router
  – end node
Addressing and Routing
Global and Local

Addressing and Routing
• IPv6: needed to connect to the Internet of Things
  – Leverage decades of Internet experience:
    Routing, Security, Maintenance
  – Adaptation available for Low-power, Lossy Networks (LLN)
• Routing over LLN (ROLL)
  – Optimized for saving energy
  – Adapt unicast and point-to-multipoint
  – Adapt to restricted frame-sizes at link layer
  – Trading off efficiency and generality
• 6LoWPAN: IETF draft with IPv6 support for LAN with limited resources
  – Adapting packet sizes
  – Address resolution
  – Taking into account power limitations
  – Accounting for disparate optimization
  – Negotiating routing
  – Support for device discovery