Proposed Node and Network Models for M2M Internet

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Outline

• Background: M2M and IoT
• M2M-NW architecture
• Proposed gateway for M2M and IP networks
• NW model for M2M internet
M2M and IoT

M2M: Remote monitoring or automated machine control through (wireless) machine-to-machine communication

IoT: Variety of nodes and devices are networked using common communication protocols on global scale
Wireless Sensor Network (WSN)

- Mesh topology and multi-hop routing
- Routing protocols for ad-hoc mesh networks (AODV, OLSR, etc.)
- Applied to Smart Utility Network (SUN)/Smart Meter
- Many related standards: Zigbee, ISA100.11a, Wireless HART, etc.
M2M-NW Gateway

- Basic gateway architecture
- Placed between non-IP (i.e. WSN) and IP networks
- Parent node function is integrated
- Translates IP to non-IP protocol and vice versa
- Still using WSN-specific semantics (no interoperability between protocols)

![Diagram of M2M-NW Gateway]

- Internet
- LAN (Ethernet, WLAN, etc…)
- Gateway
- WSNs
  - IEEE 802.15.4
  - Zigbee
  - ISA100.11a, etc…

- Sensors/ actuators
  - Non-IP Media and network protocol translation
  - IP
M2M-NW Architecture

- M2M-NWs connect to home/office LAN via gateways
- Reachable from Internet through home/mobile access links
- Can be set up outside with mobile access link
- Home and mobile routers can organize ad-hoc networks

![Diagram of M2M-NW Architecture]

- BB (Home) Router
- Access link
- Internet
- Mobile, WiFi, etc.
- Mobile Router
- Gateway
- M2M-NW
Proxy type gateway

- Translate application layer protocols as well as IP
- Map non-IP-specific commands to IP-based application protocols (e.g., SOAP, REST)
- Easy M2M and IP network integration
- Each M2M node is not reachable with IP address
• **6LoWPAN (IETF RFC 4944)**
  – Specifications for transmitting IPv6 packets in IEEE 802.15.4 data frames (IPv6 over WSN)
  – Adaptation layer between IPv6 (L3) and 802.15.4 (L2) layer
    • Packet fragmentation and reassembly to fit maximum frame size (102 octets)
    • Packet delivery over link-layer mesh
    • Multicasting over mesh network
    • Address mapping and header compression
  – M2M-NW can be integrated seamlessly into IP network (Every sensor node has IPv6 address)

• **Constrained Application Protocol (CoAP)**
  – IETF Constrained RESTful Environment (CoRE) WG
  – Defines application layer (web) protocol for resource constrained nodes (over 6LoWPAN)

• **Aiming to connect M2M-NWs to Internet without protocol translation**
Challenges for M2M-NW gateway

• Proxy type
  – Limited integration
    • No direct IP connectivity to M2M-NW nodes
    • Requires additional mechanism to identify each M2M-NW node from Internet

• 6LoWPAN + CoAP
  – Need IP protocol stack on M2M-NW nodes
  – MTU difference at data link layer
    • Packet fragmentation requires M2M-NW nodes for buffering and reconstructing fragmented packets
  – IEEE 802.15.4g will extend PHY data frame size from 127 to 2048 octets (no need for fragmentation?)

• Common to both
  – “Sleeping nodes” are not always on
Proposed gateway

- Produce virtual node process for each physical node in gateway
- Virtual node can be seen as one full set of IP nodes from IP networks
- Protocol translation and proxy for sleeping nodes are encapsulated in virtual node
Modeling IP-based M2M-NW

• Mapping M2M-NW to IP subnet
  => Compatibility with existing IP networks

• Routing: Mesh-under
  – Maps M2M-NW to single broadcast domain (i.e. IP subnet)
  – Construct star topology network
    • All M2M nodes are connected by one IP hop in same IP subnet
    • Gateway acts as IPv6 router (Default gateway)
  – Maintain Ethernet abstraction
    • “shared networks support link layer broadcast” [RFC3819]
  – Multi-hop routing is handled by link layer

• Cf. Route-over
  – Compose mesh (multi-hopping) topology at IP layer
  – Every M2M node appears as “6LoWPAN router” (one IP hop)
  – RPL: IPv6 Routing Protocol for low power and lossy networks
    • Being standardized at IETF
Proposed NW model for M2M Internet

- Home/office networks consist of different types of M2M-NWs and routers
- Assume home/office network as like “small autonomous system (AS)” that can be interconnected to other neighboring small AS

Home network = Small AS

M2M IP subnet

IP subnet

Proposed GW

BB (Home) router

Mobile router

Mobile, WiFi, etc.

Access link

IP routing (neighbor)

Wireless link

Small AS

M2M IP subnet

M2M IP subnet
Interior routing in small AS

- IETF Homenet WG
  - Developing architecture draft for networks consisting of multiple routers and subnets in relatively small residences
  - Key issues: prefix configuration, routing management, name resolution, service discovery, network security
  - Assuming LLNs (i.e. M2M-NWs) are also connected

=> Relevant to this study

Prefix assignment
- DHCPv6 PD++
- OSPFv3++

Routing
- OSPFv3

ISP access link

Home GW

Guest segment

WLAN segment

Home sensor segment

Interior router

Home automation segment
Small AS routing and multi-homing

- Multi-homing provides redundancy by multiple uplinks to Internet
  - Multiple links to ISPs
  - Provider-independent addresses
  - Border Gateway Protocol (BGP) speaking routers
- Applying full set of inter-domain approaches (PI address and BGP) to each small AS is unrealistic (i.e. fractioned address blocks and huge routing tables)
- Various techniques for site multi-homing/mobility by IETF/IRTF
  - Separate site local address from Internet core (provider-aggregatable) address
  - Eliminate requirement for BGP peering with ISP
    - Mobile IP/NEMO (network mobility) /MANET (mobile ad-hoc networks)
    - “Identifier/Locator Split”: Identifier-Locator Network Protocol (ILNP)
    - “Map and Encapsulate”: Locator/ID Separation Protocol (LISP)
- Cf. RFC6115: “Recommendation for a Routing Architecture”
Small AS routing and multi-homing (cont’d)

• Key concept: locator/identifier separation
  – Distinguish between locator and identifier in concept of IP address
  – Locator
    • Network “topology-dependent” name
    • Indicate place in network
    • Use locators for routing
  – Identifier
    • “Topology-independent” name for logical node
    • Stable during location or uplink changes

• ILNP
  – Split 128-bit IPv6 address into 64-bit locator and identifier
  – Only locators are used for network-layer routing

• LISP
  – Use two separated addresses for locator and identifier
  – Encapsulate packets of identifier address into those of locator address at edge routers
  – Routing by locator address

=> Try to apply ILNP to multi-homing via neighbor’s small AS
Summary

• Gave overview of M2M gateway and network architecture for achieving M2M Internet

• Proposed M2M gateway model
  – Enables seamless integration of non-IP M2M-NWs with IP networks while resolving issues characteristic of WSNs

• Proposed network model for M2M internet
  – Maps M2M-NW to IP subnet (mesh-under approach)
  – Introduces small AS concept
  – Enables IP addressing and routing consideration

• Future Study
  – Examine feasibility of proposed gateway through prototyping and practical application study
  – Evolve concept of IP addressing and routing and develop routing mechanism for mesh network of small AS