NTT

Proposed Node and Network Models for M2M Internet

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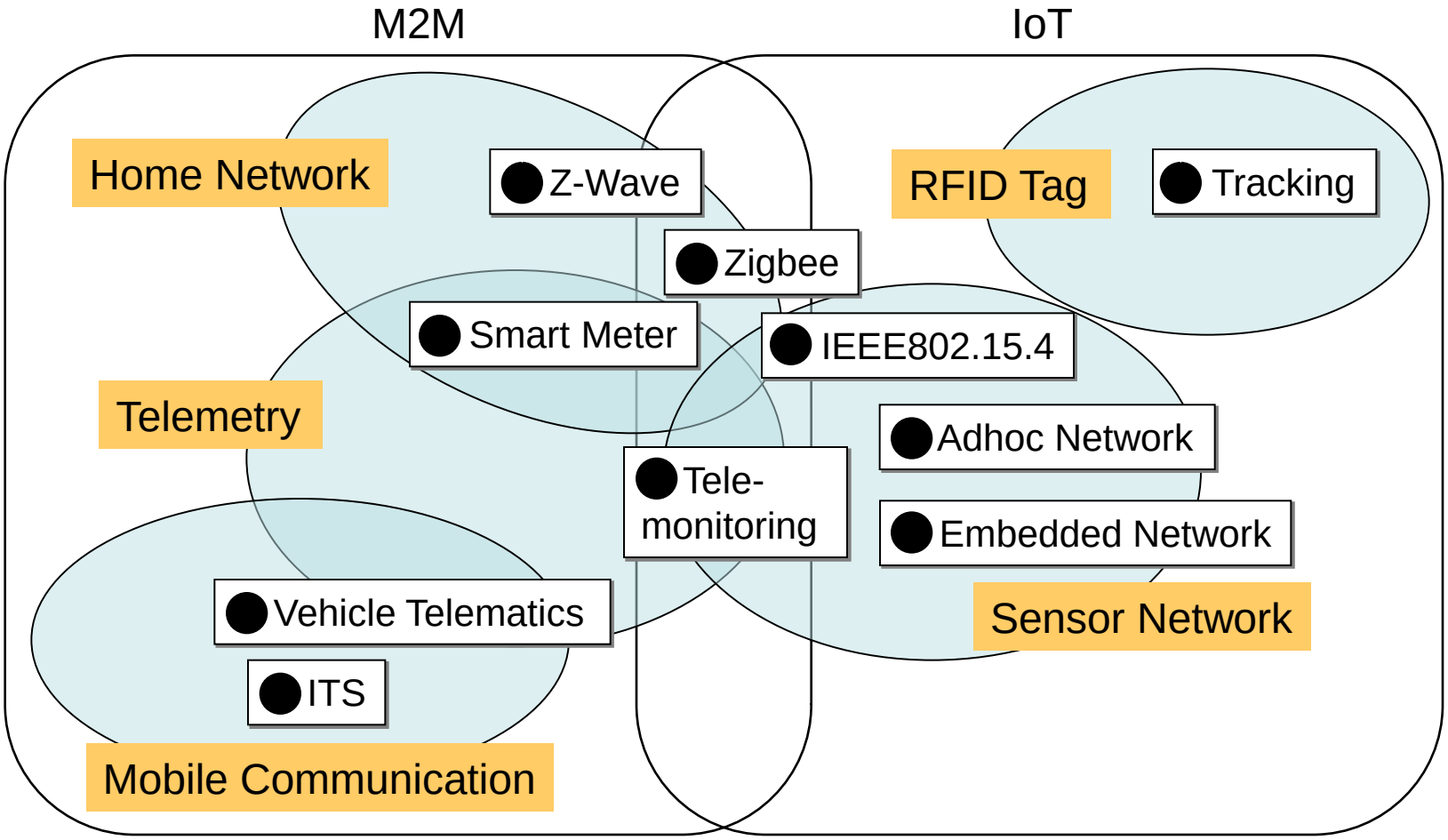
Outline

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

M2M and IoT

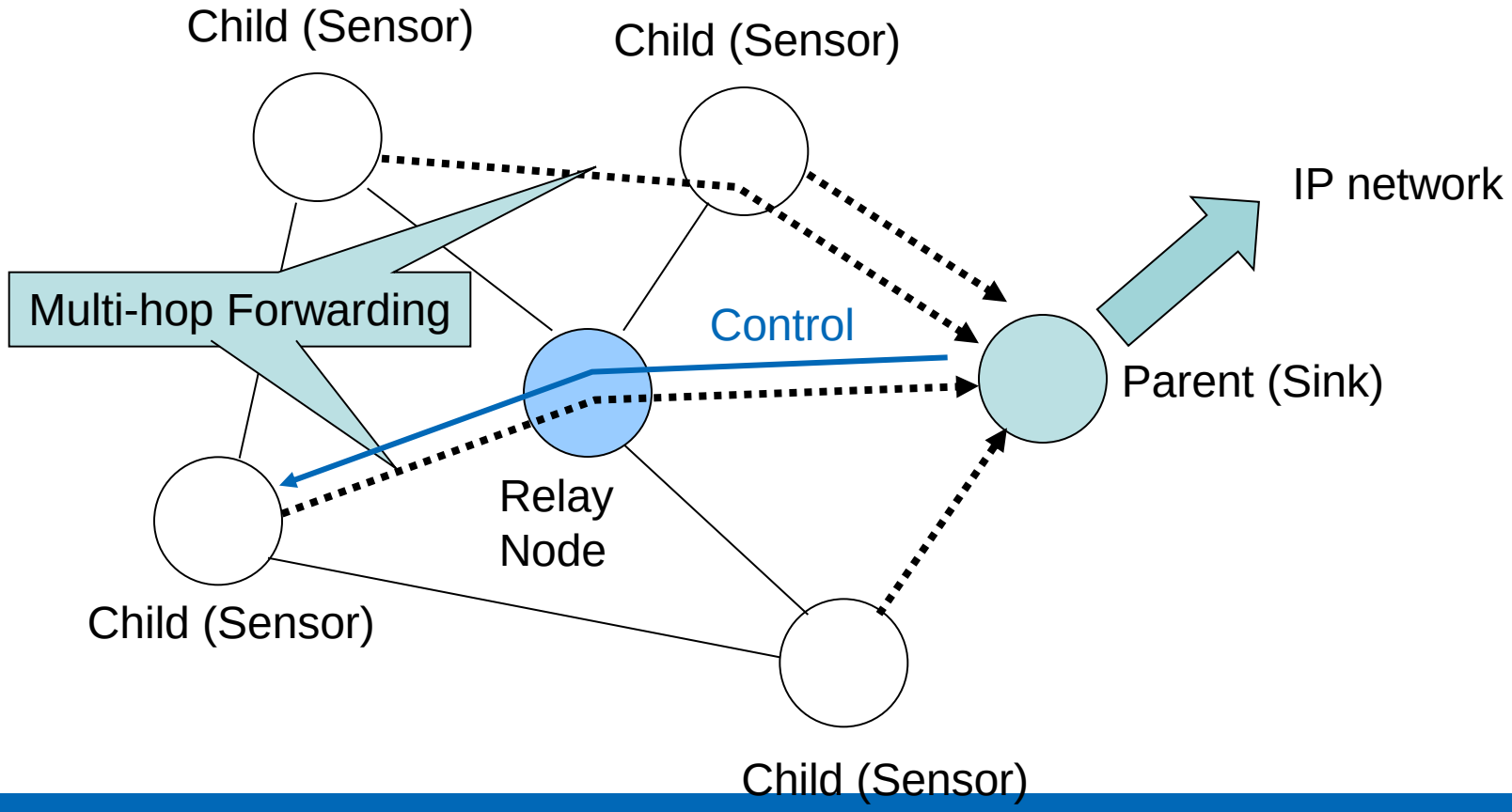
M2M: Remote monitoring or automated machine control through (wireless) machine-to-machine communication

IoT: Variety of nodes and devices are networked using common communication protocols on global scale



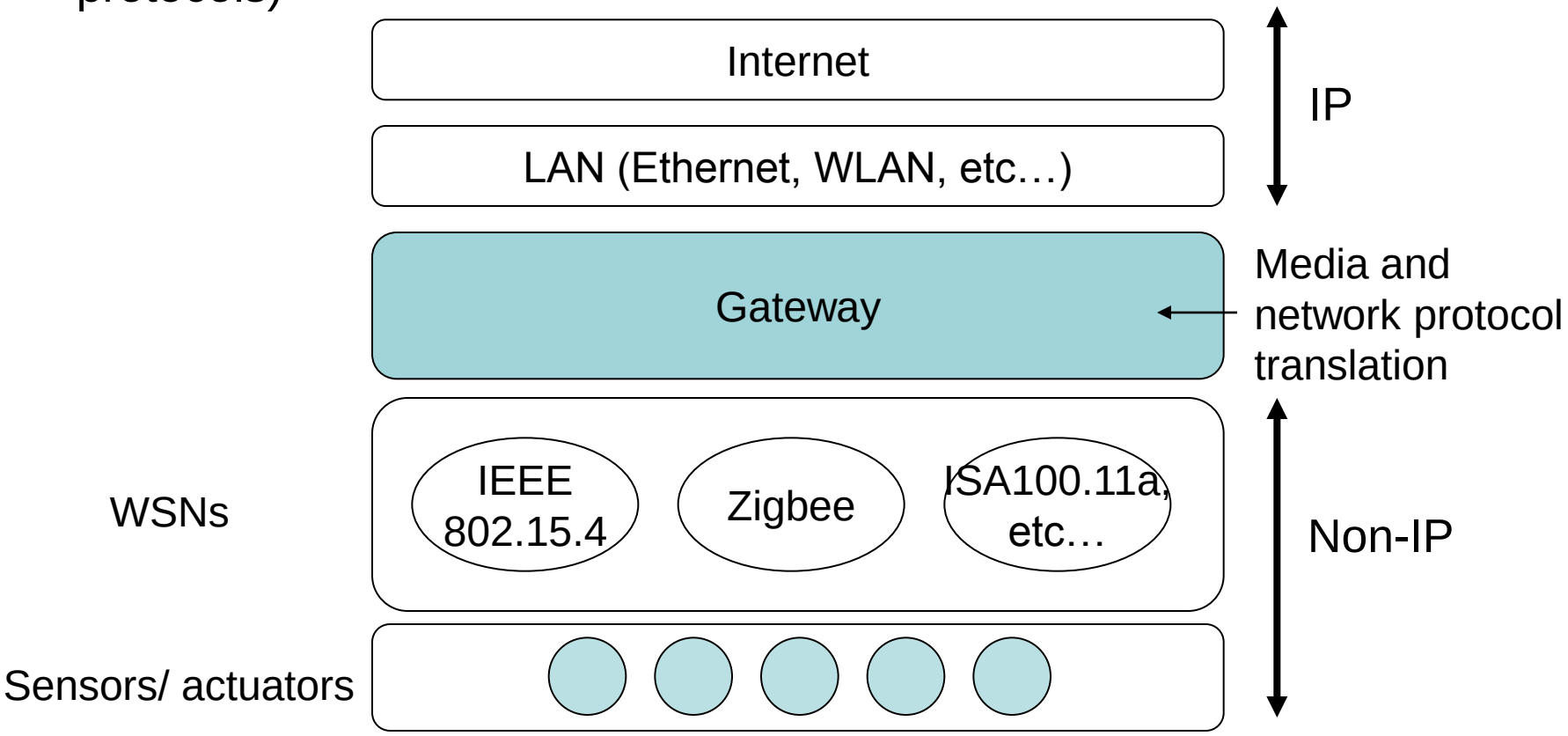
Wireless Sensor Network (WSN)

- 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.



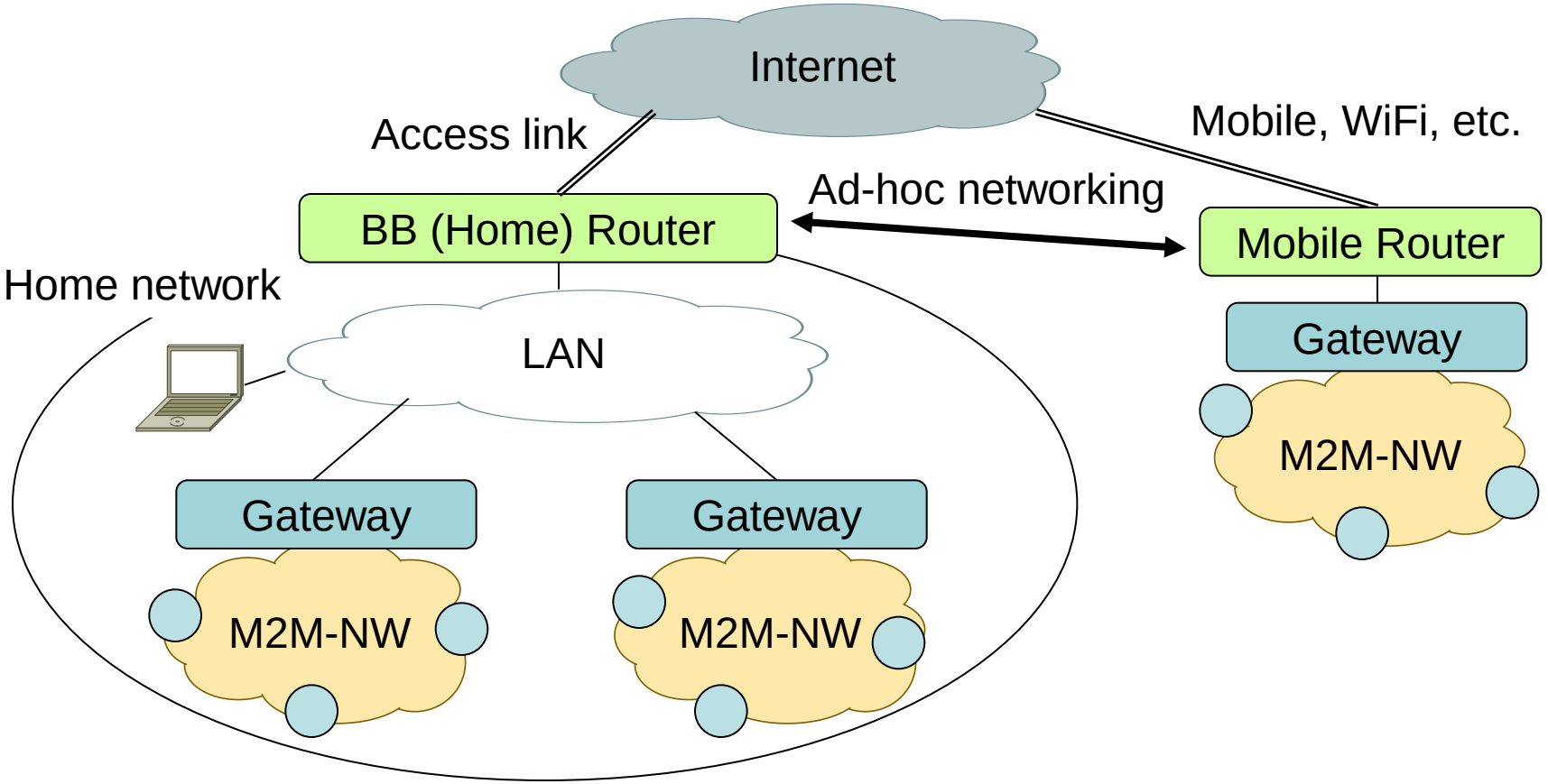
M2M-NW Gateway

- 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)



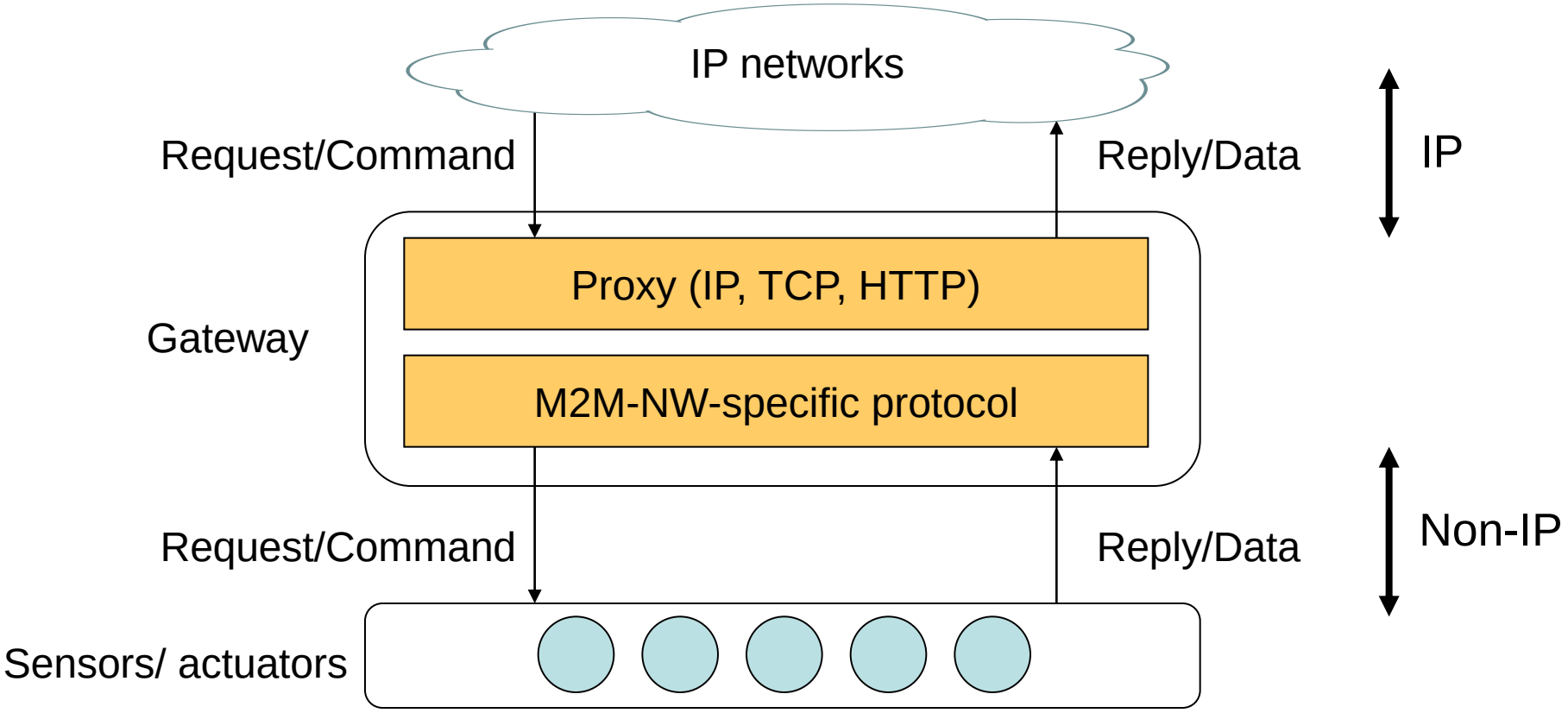
M2M-NW Architecture

- 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



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 + COAP

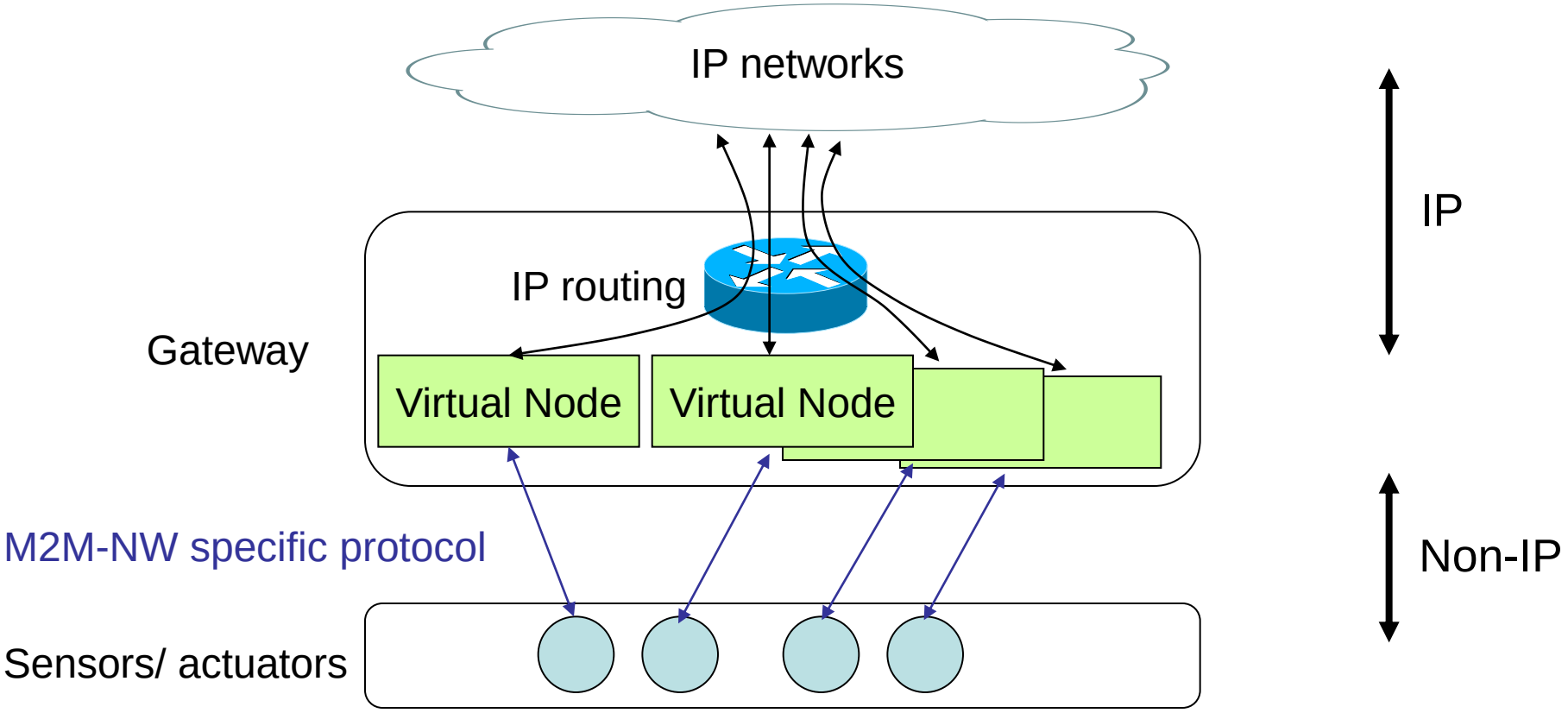
- 6LoWPAN (IETF RFC 4944)
  - Specifications for transmitting IPv6 packets in IEEE 802.15.4 data frames (IPv6 over WSN)
  - Adaptation layer between IPv6 (L3) and 802.15.4 (L2) layer
    - Packet fragmentation and reassembly to fit maximum frame size (102 octets)
    - Packet delivery over link-layer 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



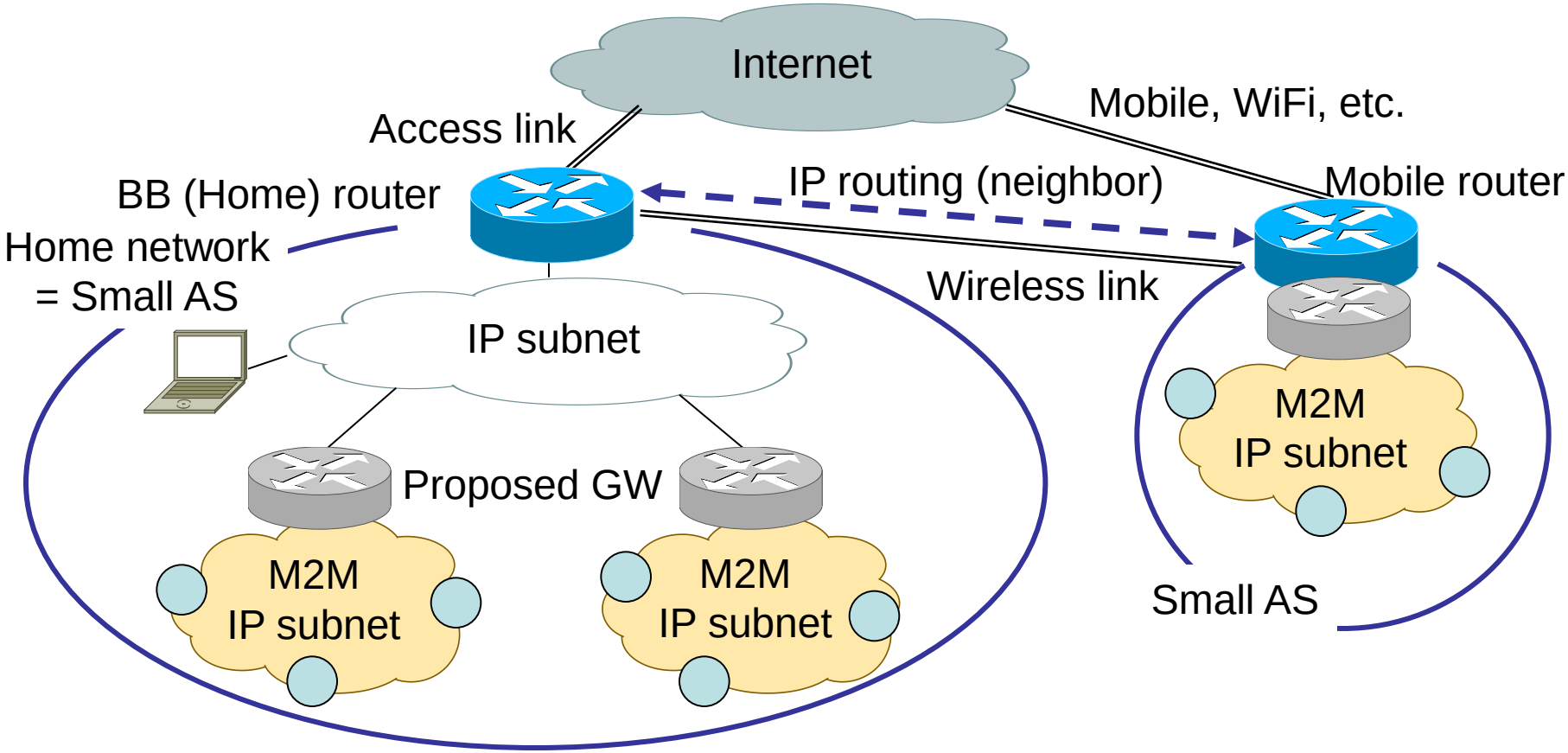
Modeling IP-based M2M-NW

- 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

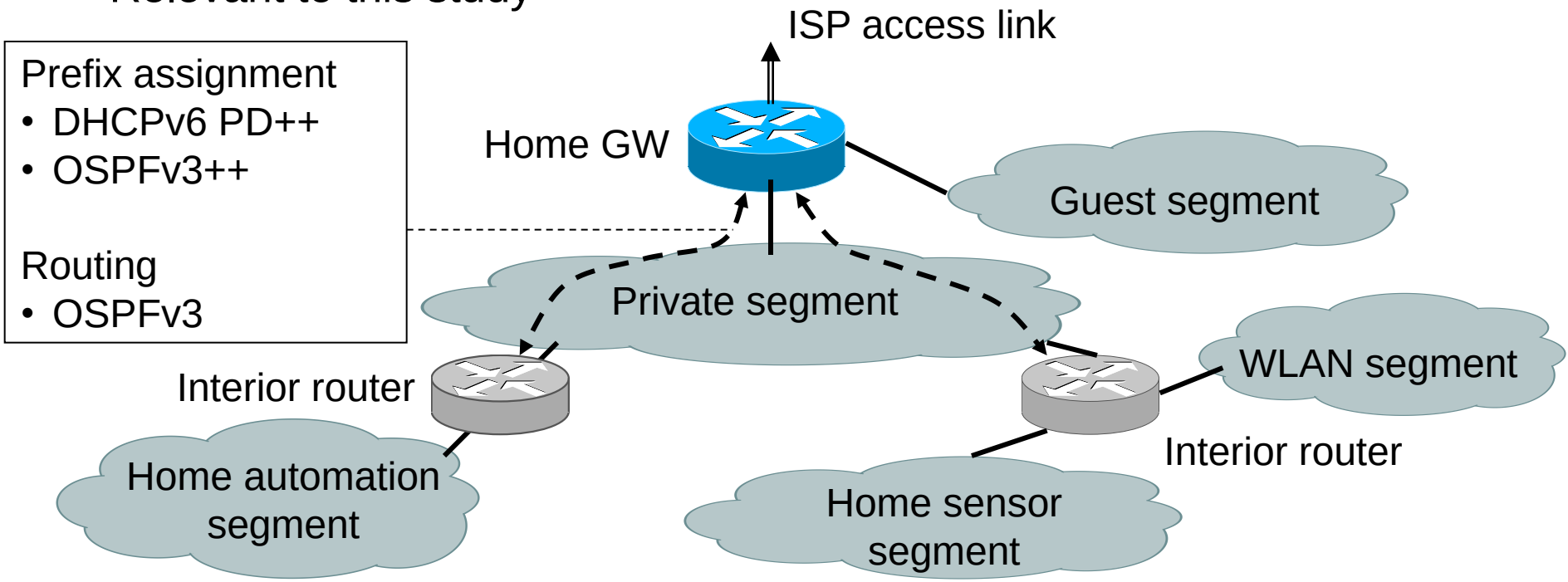
- Home/office networks consist of different types of M2M-NWs and routers
- Assume home/office network as like “small autonomous system (AS)” that can be interconnected to other neighboring small AS



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



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