Internetworking Between ZigBee/802.15.4 and IPv6/802.3 Network

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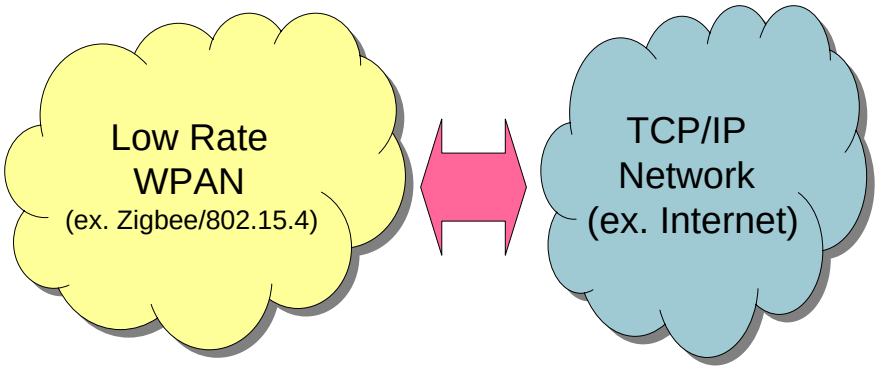
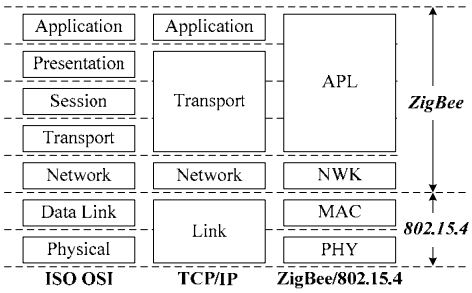
Introduction



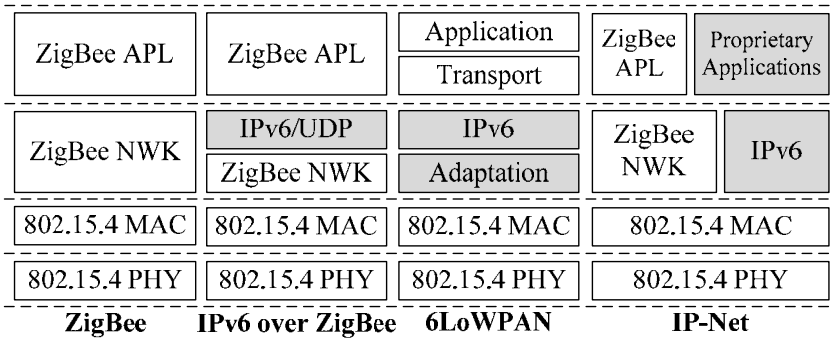
Introduction (cont.)

- Most popular Low-Rate WPAN
  - L1 & L2:
    - IEEE 802.15.4
  - L3 and above:
    - ZigBee



- Motivations:
  - All-IP network is a trend, but ZigBee is not compatible with IP network
  - IP-based sensor networks require lots of addresses, IPv6 might be a solution
  - IPv6 provides some useful functions

Related Works



Related Works – IPv6 over ZigBee

- Straight forward method
- Problem:
  - Maximum PHY service data unit: 127 bytes
    - Only 94bytes(w/o L2 security) or 81 bytes (with L2 security) can be used for L3 data frame
  - IPv6 requires:
    - 40 bytes basic header + extension headers
    - 1280 bytes MTU

Related Works – 6LowPAN

- Newly developed solution
- Problem:
  - [ref.] Kushalnagar, N., Montenegro, G., and Schumacher, C. 6LoWPAN: Overview, Assumptions, Problem Statement and Goals. IETF Internet Draft draft-ietf-6lowpan-problem-08 (work in progress), February 2007.
  - No ZigBee NWK, all the routing structures, address assignment, and data forwarding must be redesigned.

Related Works – IP-Net

- A proprietary solution which is designed by the Helicomm Inc.
- A dual stack approach.
- Problem:
  - Only one of IPv6 or ZigBee can be used at the same time.
  - No internetworking.
  - Has all the problems that 6LoWPAN has.

Related Works – Translation Solution

- Sakane, S., Ishii, Y., Toba, K., Kamada, K., and Okabe, N. A translation method between 802.15.4 nodes and IPv6 nodes. In Proceeding of the International Symposium on Applications and the Internet Workshops 2006 (SAINT 2006) (Phoenix, Arizona, USA, January 23-27, 2006), 34-37.
- A NAT-PT liked internetworking solution.
- Problem:
  - users must pre-configure their hosts with fixed gateway address.
  - The NAT-PT like design also breaks many end-to-end features.
  - No service discovery extension.
  - No cross regions transmission (only works with one IPv6 network and one ZigBee network).

The Overlay Internetworking Design

Design Criteria

C.1
C.2
C.3
C.4
C.5

C.1 Each ZigBee node should be assigned with a global unicast IPv6 address.

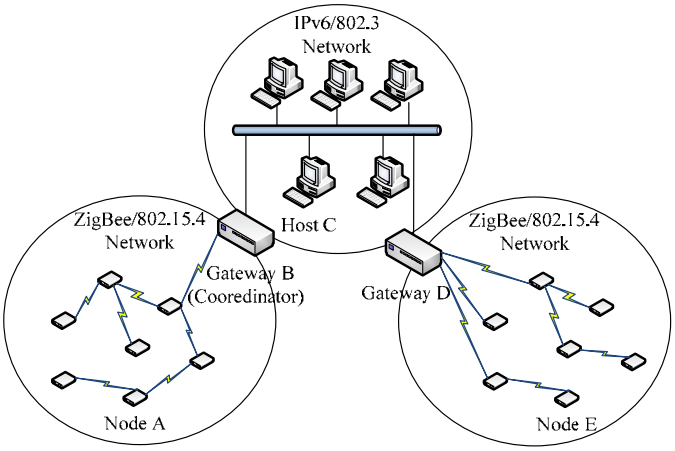
C.2 Each IPv6 host which may communicate with ZigBee node should obtain a ZigBee address.

C.3 Service discovery should be propagated to different network domain.

C.4 Broadcast data in ZigBee network should be transferred to proper IPv6 hosts.

C.5 Data packet transformations in the gateways should be as simple as possible and should not break the end-to-end model above the transport layer.

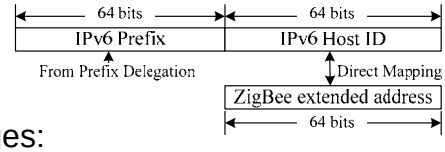
Network Diagram



Function 1: IPv6 Prefix Delegation

C.1
C.2
C.3
C.4
C.5

- Goal: Assign each ZigBee node with an IPv6 address
- Gateway is a more powerful ZigBee device with Ethernet interface but may not be powerful enough for all IPv6 router functions.
- With the delegated prefix (pseudo), every ZigBee device can have its own IPv6 address.



- Advantages:
  - Pseudo address: No IPv6 Stateless Auto-configuration at ZigBee devices.
  - The gateway can easily remove the prefix part of the destination address and get the destination ZigBee address.
- Fulfilled Criteria: C.1 and part of C.5

Function 2: UPnP

C.1
C.2
C.3
C.4
C.5

- C.2
  - ZigBee PAN ID -> keyword of the type of device in UPnP SSDP -> for IPv6 host to get ZigBee address
- C.3
  - ZDO ←(transform@gateway)→ SSDP(XML format)
- Do not have to manage a lot of pre-assigned parameters.

Function 3: IPv6 Multicast

C.1
C.2
C.3
C.4
C.5

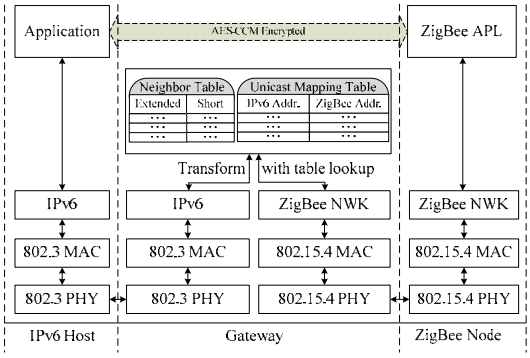
- Broadcast is needed in ZigBee network.
- <if> ZigBee broadcast <-> IPv6 all node multicast
  - <then> huge amount of IPv6 all node multicast message will crash the low data rate ZigBee network.
- We set up an IPv6 multicast group for each PAN ID. The gateway which is at the same network of the ZigBee coordinator will act as the rendezvous point of the multicast group.

Function 4: Extended IP Switching

C.1
C.2
C.3
C.4
C.5

- Unlike NAT-PT solution, we use an IP-switching like mechanism to accomplish our purpose.
- All the data packet transformations are done below the network and the NWK layer, with simple header replacement.
- Without digging information from APL payload, the replacement will work with a simple table lookup.
- Because the entire NWK payload can keep untouched, we can enable the AES-CCM at APL layer to safeguard our data security.

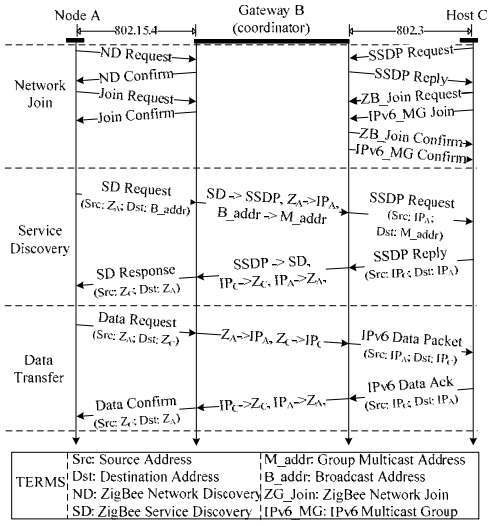
Address Assignment



Examples of Transmission Flows

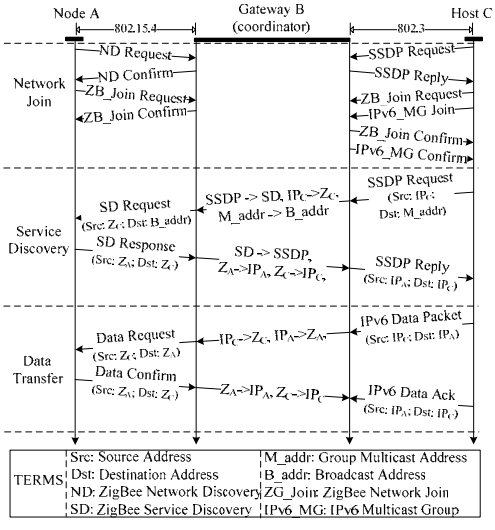
From ZigBee/802.15.4 to IPv6/802.3

- Node A (ZigBee/ 802.15.4) -> Gateway B-> Host C (IPv6/802.3)



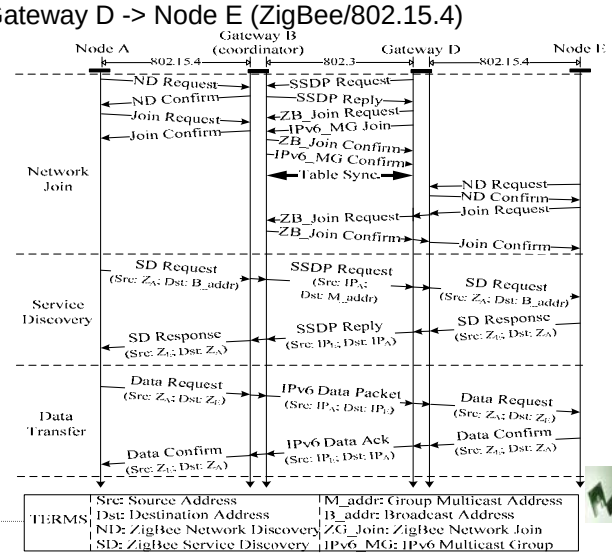
From IPv6/802.3 to ZigBee/802.15.4

- Host C (IPv6/802.3) -> Gateway B-> Node A (ZigBee/ 802.15.4)



Cross Regions Example

- Node A (ZigBee/802.15.4) -> Gateway B -> (IPv6/802.3) -> Gateway D -> Node E (ZigBee/802.15.4)



Conclusion

- We present a novel gateway design which can overlay the ZigBee/802.15.4 and the IPv6/802.3 networks together and internetworking among them.
- Can easily be extended to all kind of IPv6 networks such as IPv6/802.11, IPv6/UMTS, etc.
- The mechanism works on Layer 3 and below so that it can keep the APL layer security if needed.
- A known problem is the "address in address" issue. It is a future work.

Acknowledgement

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Thank you!

Questions or comments?