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Connecting IPv6 Sensor Network with Internet

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Sensor networks are based on the collaborative efforts of many small autonomous nodes using sensors to cooperatively gather physical or environmental information and are distinguished by constrained capability of nodes, high density, distributed, multi-hop, self-organized, dynamic topology. With the pervasive and ubiquitous characteristics, sensor networks enable people to get any available information anytime and anywhere, which improves human's quality of life and productivity.

We have recognized the importance of IPv6 sensor networks:

IPv6 has many obvious advantages in the next generation Internet. Firstly, it has large address space so that it is more suitable for higher density of WSN. Every sensor node of WSN could have a unique IP address. Secondly, IPv6 is a rich protocol with address auto-configuration, security mechanism, mobility management etc. When wireless sensor networks consist of large scale nodes, the address auto-configuration of IPv6 requiring no user involvement is more convenient and suitable for WSN. Besides, IPv6 network is convenient to interconnect with current Internet based on IP technology.

Wireless sensor networks cannot operate in complete isolation, they should access into Internet to send physical information and receive commands especially when placement region is far away from sensor servers. Though many network architectures have been proposed such as Zigbee, Sensor-Net, IPv6 sensor network will be a better choice comparing with other methods since TCP/IP is the factual standard for current network and IPv6 is core protocol of next generation Internet. We adopt IPv6 protocol in the wireless sensor networks.

We have recognized different ways to connect IPv6 Sensor Network with Internet:

We have studied IPv6 sensor networks since 2003, and we consider that the interconnection ways with Internet are based on different applications demands and carrying networks between IPv6 sensor networks and Internet. We propose two major suggestions about Interconnection architectures:

- **Direct access architecture: IPv6 senor networks directly connect with Internet without any intermediary devices**

The direct access architecture seems simple since each sensor node has embedded into TCP/IPv6 protocol suite and has a unique IPv6 address in the world. Therefore, any Internet device, such as user terminal and router, can directly visit

resources of sensor nodes without gateways. However, it needs high memory and computation resources to run a full TCP/IPv6 protocol suite and routing protocol in sensor node. Though we have implemented our compact protocols in low-power micro-controller (Atmega 128L) and also many other lightweight protocol stacks have been proposed, richer hardware resources like CrossBow Stargate and UCLA LEAP2 are needed for more complicated applications. The direct access architecture is suitable for application scenarios such as smart home and remote medical system where resource restriction demands are not major factor.

- **Proxy architecture: Special gateways are needed to interconnect IPv6 sensor networks with Internet**

When hardware resources are constrained and simple application demands is required for sensor networks, the proxy architecture is straightforward and flexible so that all interactions between IPv6 sensor networks and Internet are implemented through the special gateways. Though the gateways can be operated as front-end and the communication protocol may be chosen freely, the reliable end-to-end communication will not be realized. It is a good choice to use the proxy architecture only to relay the data between IPv6 sensor networks and Internet. Considering the Internet with IPv4 and IPv6 coexistence, we suggest two main ways depending on the different carrying networks.

1) Based on IPv6 carrying networks, the gateways only relay IPv6 packets.

The scenarios may be suitable for the gateways access into IPv6 Internet where the Internet infrastructure is convenient. We deploy each sensor node with IPv6 link-local address and IPv6 global unicast address to send data. IPv6 Link-local address is for intra-communication with other sensor nodes, whereas IPv6 global unicast address is to interact with Internet. When the gateways receive IPv6 packets with Link-local address, it will route the packets in IPv6 sensor networks. Otherwise it will relay the packets with IPv6 global unicast address into the Internet. We implement the proxy architecture in campus monitoring application and it shows good relay efficiency.

2) Based on IPv4 carrying networks, the gateways encapsulate IPv6 packets and relay IPv4 data.

The scenarios may be suitable for the gateways access into IPv4 Internet so that the gateway should configure the IPv4 and IPv6 dual stacks. We suggest that the entire IPv6 packets which interact from IPv6 sensor networks to Internet are encapsulated as IPv4 data and are relayed by the gateways. The Internet user decapsulates the data through a specific tunneling mechanism of IPv6 into IPv4 application. We implement this proxy architecture in agricultural monitoring applications without Internet infrastructure and the gateways access into Internet by GPRS/CDMA data services with IPv4 carrying network.