Integration of Wireless Sensor Networks to the Internet of Things using a 6LoWPAN Gateway

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Outline

- Introduction {similar to Culler slides}
- 6LoWPAN details {only top level}
- Gateway Prototype
- Experiments and Analysis
- Conclusions and Critique

Introduction

- This paper does actual experiments and NOT Cooja simulations.
- Motivation for investigating 6LoWPAN with IEEE802.15.4 is these sensor nodes can be integrated with any IP network or the Internet.
- Most of the results are essentially straightforward and provide little new insight.

IPv6 and 6LoWPAN Details

- 6LoWPAN must support IPv6 minimum MTU of 1280 bytes.
- IEEE802.15.4 maximum frame size of 127 bytes → fragmentation.
- IPv6 uses 128 bits. IEEE802.15.4 uses 64 bits (full) or 16 bits (short) address.

6LoWPAN Adaptation Layer

- Mechanisms included:
  - 40 byte IP header compressed up to 2 bytes
  - Header compression of higher layers (TCP, UDP and ICMP)
  - IPv6 datagram fragmentation
  - Header and other information to optimize IEEE802.15.4 mesh and star topologies.

Figure 1: IPv6 Header and 6LoWPAN Compression

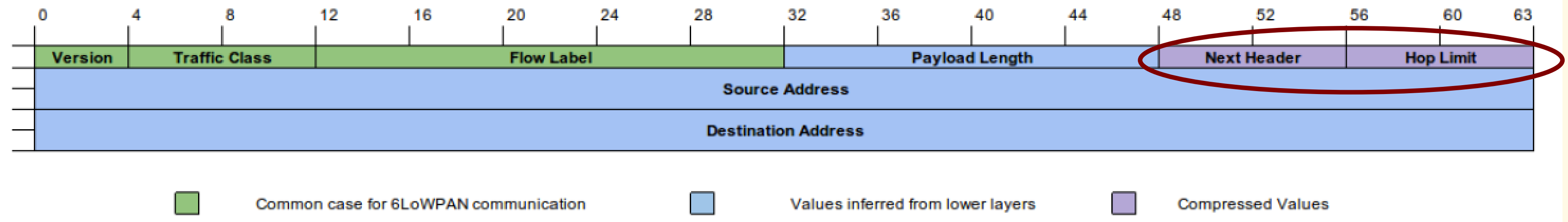


Fig. 1. IPv6 Header and 6LoWPAN compression.

- LOWPAN_HC1 and LOWPAN_HC2 from RFC4944 replaced by LOWPAN_IPHC and LOWPAN_NHC from RFC6282.
- These fields part of the modification in RFC6282.

6LoWPAN Dispatch Byte

- Identifies compression type in the IEEE802.15.4 frame:

```
+-------------+-----------+---------+
|HC1 Dispatch|HC1 Header|Payload |
+-------------+-----------+---------+
```

When the header is not compressed:

```
+--------------+------------+---------+
|IPv6 Dispatch|IPv6 Header|Payload |
+--------------+------------+---------+
```

Table I

TABLE I. 6LOWPAN COMPRESSION.

Header field	IPv6 size	Changes when 6LoWPAN is used
Version	4 bits	Version is always 6
Traffic class	8 bits	Class is always 0
Flow label	20 bits	This value is always 0
Payload length	16 bits	Inferred from the data link layer or from the fragmentation header
Next header	8 bits	Compressed using LOWPAN_NHC
Hop limit	8 bits	This value is fixed when there are no intermediate nodes
Source address	128 bits	Inferred from the data link layer
Destination address	128 bits	Inferred from the data link layer

Prototype Development

- Authors implement prototype with IEEE802.15.4 nodes and a 6LoWPAN gateway that uses an Ethernet interface to connect the nodes to the Internet.
- Atmel AVR-Atmega128RFA1 with 8-bit RISC microprocessor and 2.4GHz transceiver is base for 802.15.4 radio module (includes Contiki open source OS).

Gateway Prototype

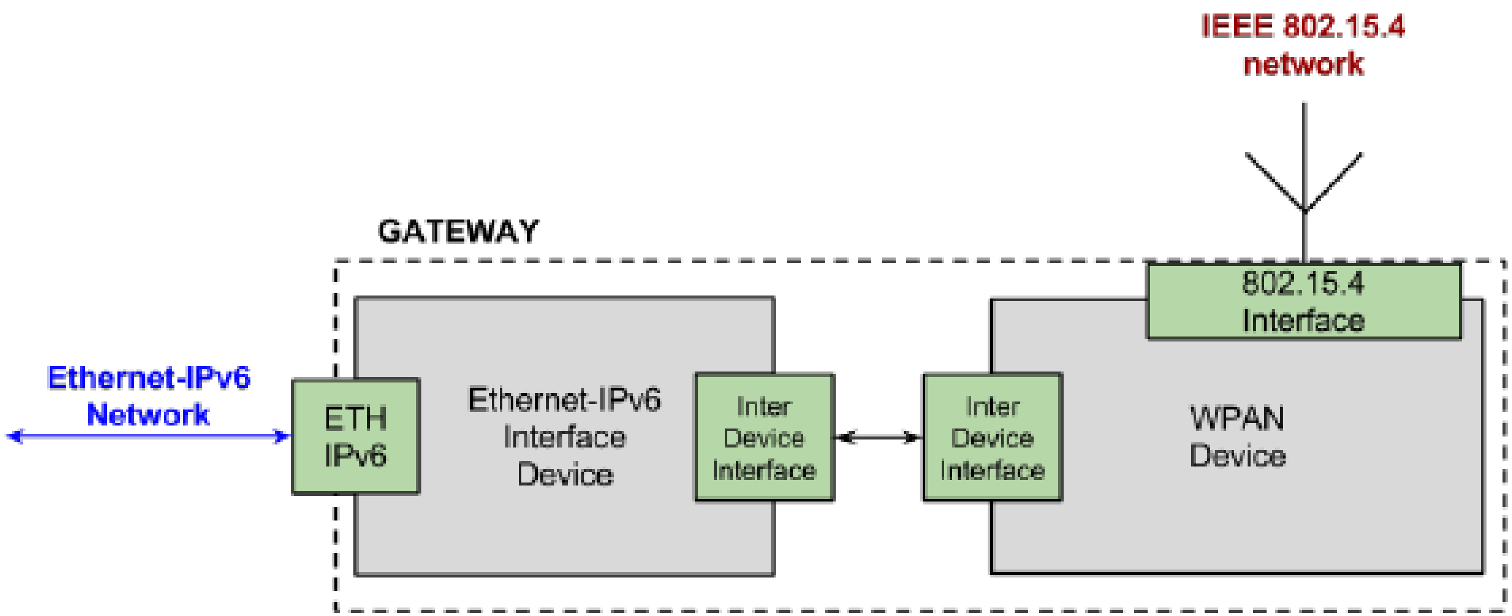


Fig. 2. Diagram of the gateway developed in this work.

Gateway developed by connecting one IEEE802.15.4 node to an Ethernet enabled device.

Prototype Details

- Contiki code was optimized for low-power devices which can use wireless TCP/IP.
  - Note: This implies using Contiki MAC layer (either Contiki-MAC or X-MAC).
- TCP/IP Contiki stack uses μIP layer validated by Cisco.
- WirelessHART and Zigbee are proprietary which hinders interoperability and connectivity to devices on Ethernet.

Prototype Details

- WPAN device based on Border Router source code in Contiki.
- Gateway needs to be powered to enable handling Ethernet interface and requirement for more RAM flash memory.

Experiments and Analysis

- Authors focus on comparing pure IPv6 versus 6LoWPAN performance only with respect to compression and fragmentation.
- First results involve UDP client/server with nodes 3 feet apart.
- Client sends another UDP packet after it received response. Timeouts considered an error.
- UDP packet size varied from 20 bytes to 520 bytes.

Experiments and Analysis

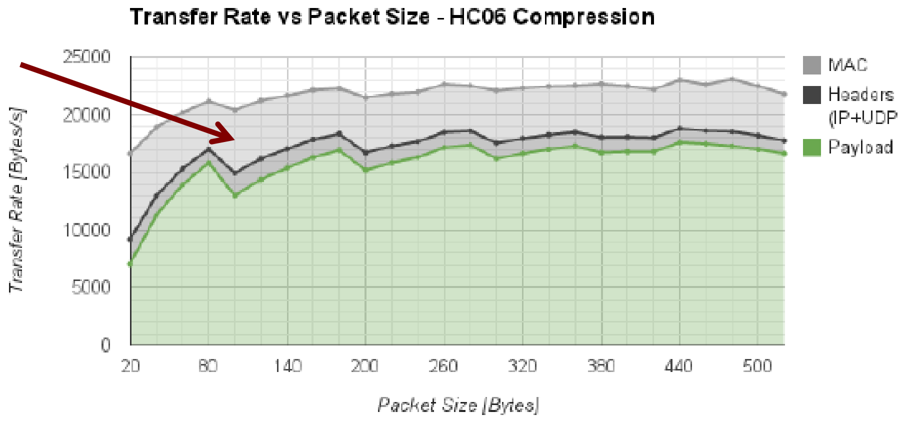
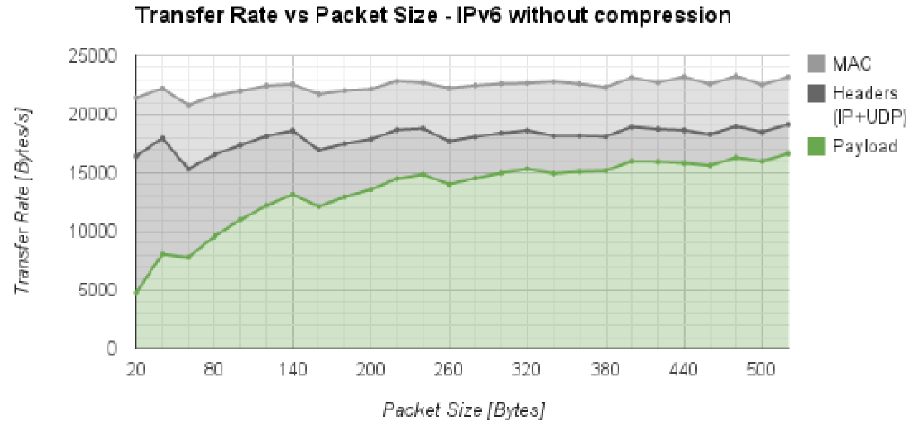


Fig. 3. Amount of data by layer – HC06 compression.



without
Fig. 4. Amount of data by layer – IPv6 compression.

- Graphs show measurements at multiple layers of μIP stack.
- Results include fragmentation. Hence, compression effect is less as compression happens in only first fragment.

Figure 5: Gateway Transfer Rate

Details NOT sufficient to reproduce or analyze.

How many sensors?

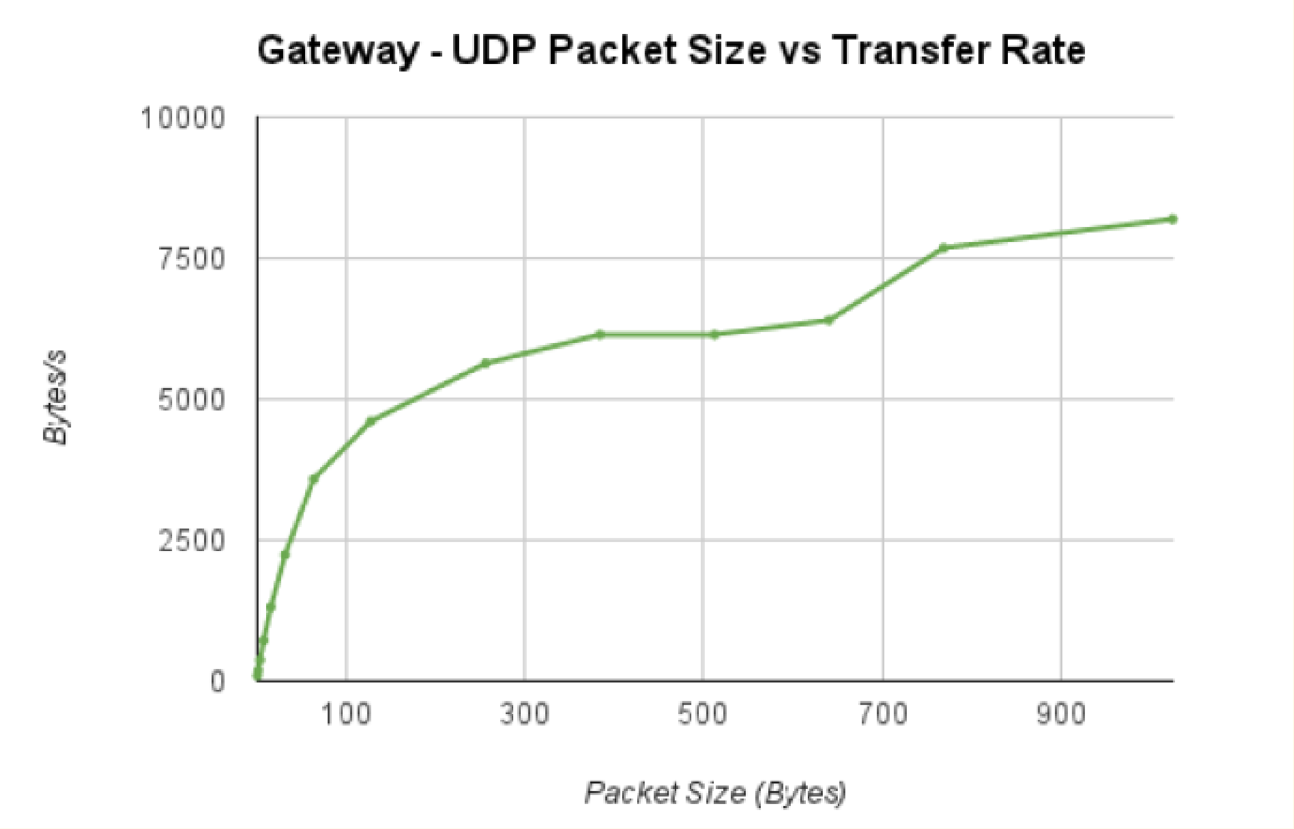
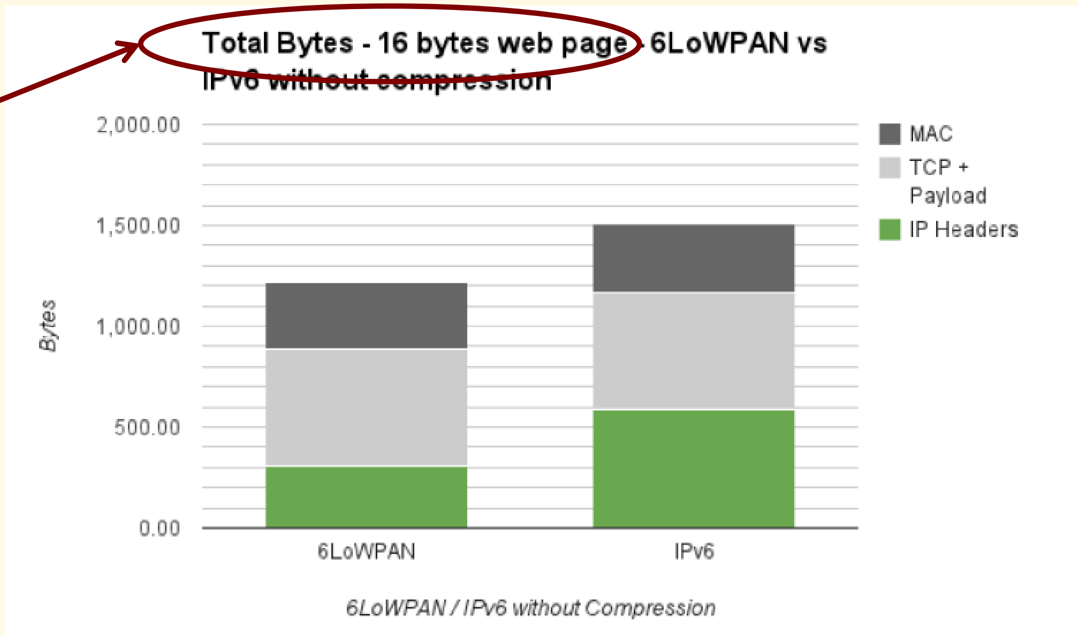


Fig. 5. Speed, considering the sum of transmission and reception data.

Figure 6: Compression Impact

Very small web page ➔ best results



- Headers dominate small packets ➔ compression gain higher for small packets!
- Overhead reduced for larger packets.
- Large page experiments impacted by available RAM.

Conclusions and Critique

- Paper presents implementation of prototype with 6LoWPAN gateway.
- Results show that compression can improve response time and data rate.
- Not much here!!
- Details missing in some cases.