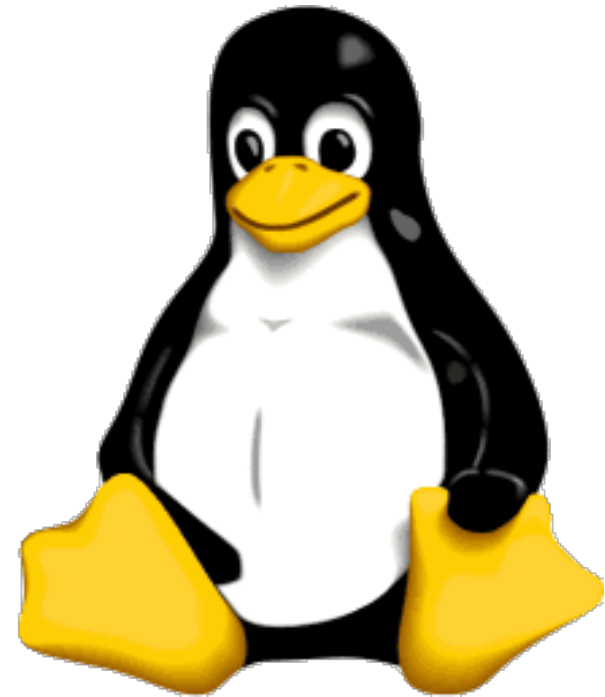


Current State of IEEE 802.15.4/6LoWPAN Stack inside the Linux Kernel

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Topics of Discussion

- Project history
- Introduction
- Linux implementation
- Future work
- Demo



Project history

- Project started in 2008
 - Project name „linux-zigbee“
 - ZigBee is an alternative to 6LoWPAN
 - License issues: ZigBee stack into kernelspace
 - Possible not released userspace ZigBee stack?
- Now: Project aims to implement 6LoWPAN
 - Open standard
 - Based on IEEE 802.15.4 networks
 - Additional 6LoWPAN upper layer protocols
 - Mainline since year 2009



Introduction

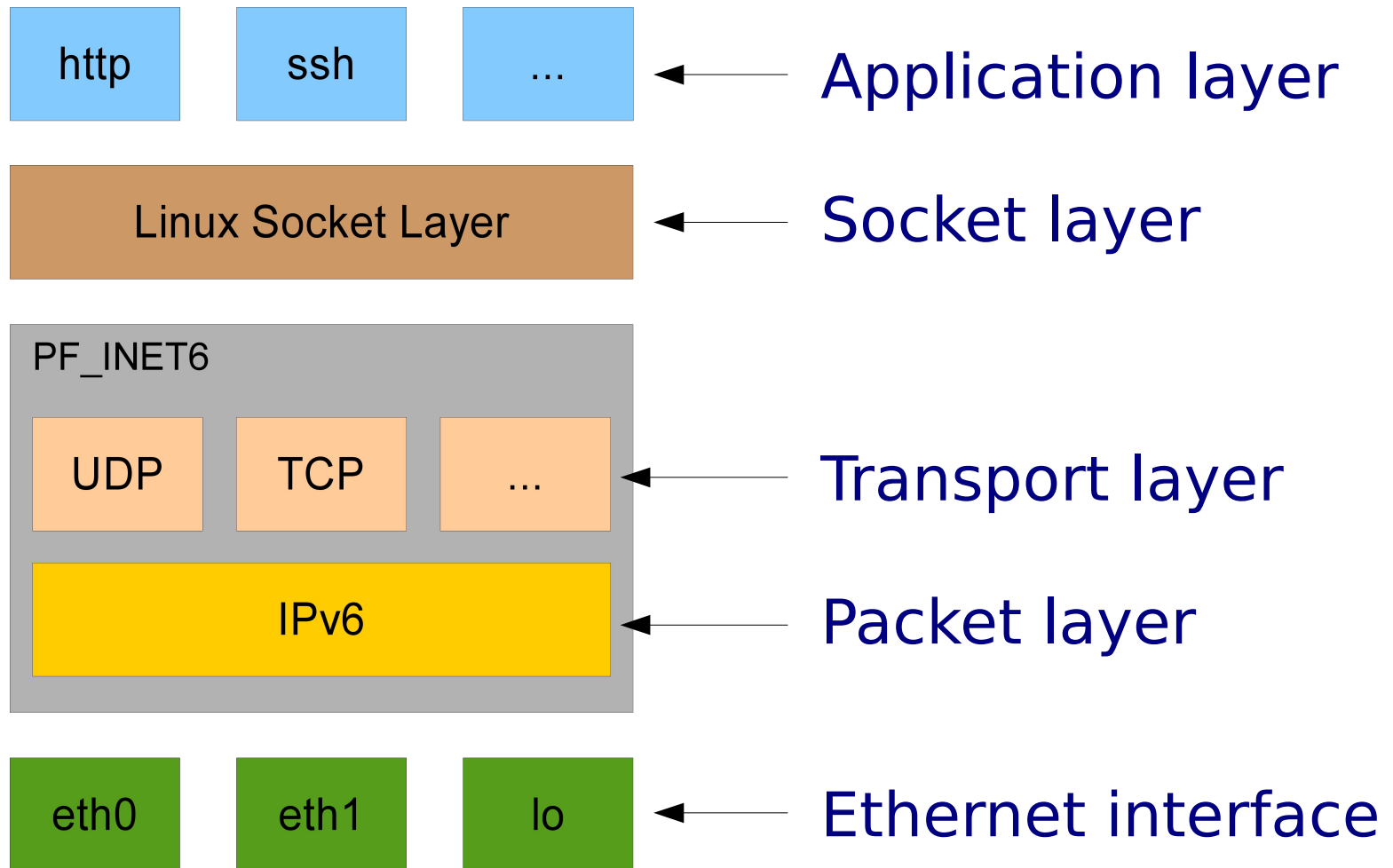
IEEE 802.15.4 and 6LoWPAN

- MAC-Layer: IEEE 802.15.4
 - Low-Rate **W**ireless **P**ersonal **A**rea **N**etworks
- 6LoWPAN
 - IPv**6** over **L**ow power **W**ireless **P**ersonal **A**rea **N**etworks
 - RFC4944 - Transmission of IPv6 Packets
 - RFC6282 - IPv6 Header Compression
- Areas of Applications
 - Sensor networks
 - Home and industrial automation
- Related work: ContikiOS
 - Most used 6LoWPAN stack implementation
 - Small stack implementation



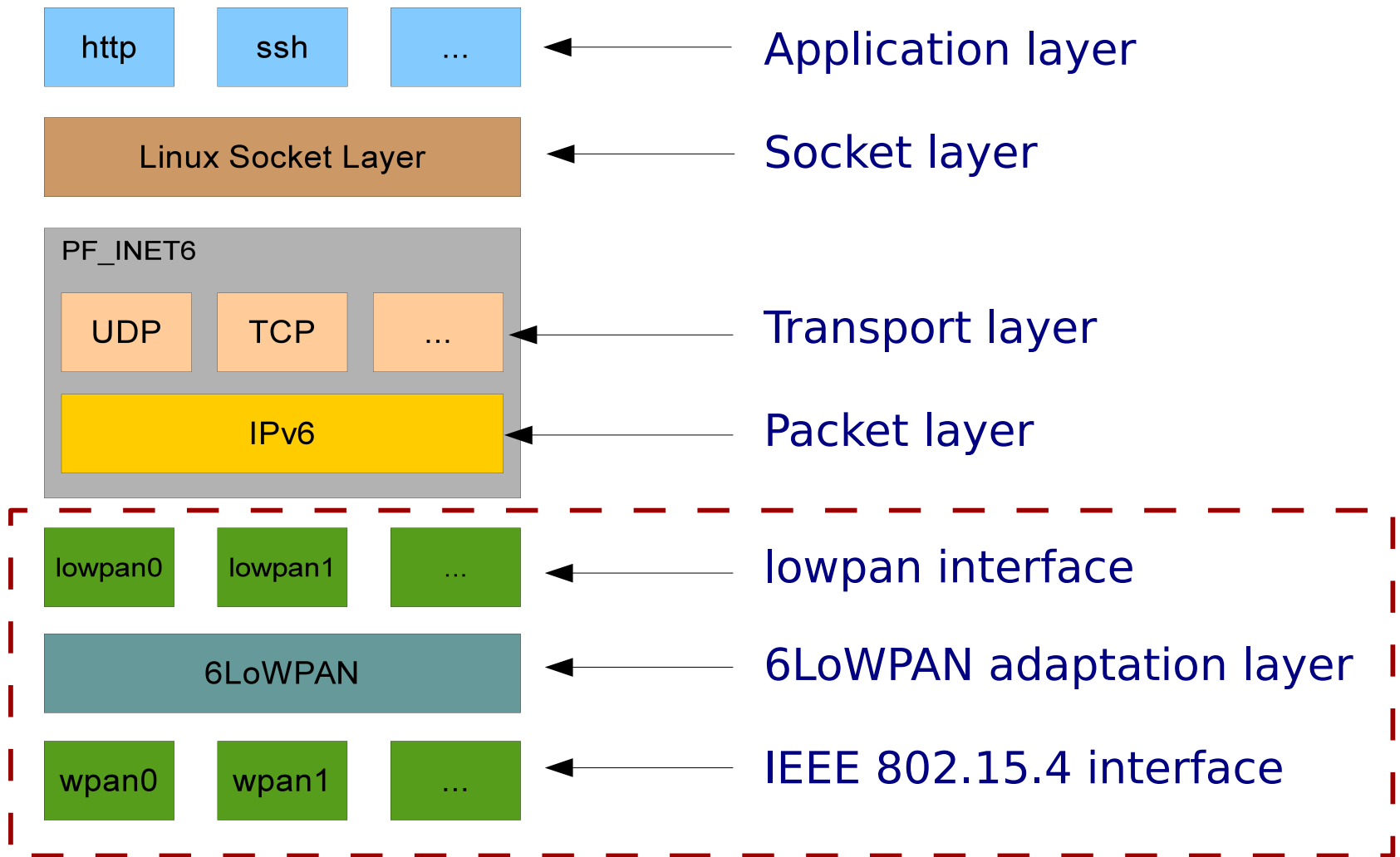
Linux implementation

IPv6 - Architecture



Linux implementation

6LoWPAN - Architecture



Linux implementation

6LoWPAN adaptation layer

- Compression of the **40** bytes IPv6 header
 - Version, traffic class, flow-label, hop-limit
 - Addresses (link-local, multicast)
 - We can remove the payload length
 - Smallest 6LoWPAN header: **3** bytes
- Compression of transport header
 - For example UDP has normally **8** bytes
 - Special port ranges and removing of checksum
 - Smallest UDP 6LoWPAN header: **5** bytes
- 6LoWPAN fragmentation
 - **127** (IEEE 802.15.4) to **1280** (IPv6) MTU



Linux implementation

Experienced issues

- Started with kernel version 3.8
- Tried to ping another 6LoWPAN node
 - Worked with non link-local addresses only
 - Fragmented 6LoWPAN packets did work in a Linux to Linux communication only
 - Got race conditions while fragmentation
- Run an UDP application
 - Random null pointer dereferences occurred
 - Didn't work on UDP 6LoWPAN port ranges



Linux implementation

Fixed issues

- IPHC (IPv6 Header Compression)
 - Address compression/uncompression
 - **Did never work correctly**
 - Reimplement necessary functions
 - UDP compression/uncompression
 - **Byte ordering issues**
 - Wrong pointer arithmetic (Null pointer problem)
 - Reverse source/destination port ordering
- **Static** IEEE 802.15.4 header size value
 - IEEE 802.15.4 header has a **dynamic** size
 - Size determined by flow control field
 - Value used in fragmentation for reconstruction



Linux implementation

Known existing issues

6LoWPAN Fragmentation

- Isn't RFC compliant
- Still having race conditions
- Issues with ACK handling on MAC layer
 - No Data Sequence Number increment
 - ACKs do not work correctly
- There are patches for a solution
 - Which is RFC compliant
 - No race conditions
 - Idea: Implement it like IPv6 fragmentation
 - Put the increment of DSN on the right place



Linux Implementation

What we have done now?

- Before
 - Ping to a contiki device wasn't possible
 - Suddenly Linux kernel crashed
- Now
 - Use of link-local addresses works
 - Connection to a contiki device works
 - IPHC and fragmentation is RFC complaint
- Bluetooth 6LoWPAN
 - Share IPv6 header compression format
 - Improving 6LoWPAN implementation



Future Work

6LoWPAN upper layer protocols

- RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks
 - Route-over: ICMPv6
 - Prototype implementation: SimpleRPL by Tony Cheneau
 - Limited functionality
 - Has lot of dependencies: python, zeromq, ...
- Neighbor Discovery Optimization for 6LoWPAN
 - Optimization for non-multicast MAC-Layer
 - Need some great idea to implement it
 - Problem: Possible handling in 6LoWPAN adaptation layer?
- CoAP for Userspace (Constrained Application Protocol)
 - HTTP for sensor networks but UDP based
 - Tested libcoap successful under Linux





Demo



Thanks!

Project Website:

<http://sourceforge.net/projects/linux-zigbee/>

Mailing list:

linux-zigbee-devel@lists.sourceforge.net

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- Werner Almesberger
- Tony Cheneau
- Alan Ott

