# ZigBee IP update
# IETF 87 Berlin

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# Introduction

- ZigBee IP is a “super” specification for an IPv6 stack
  - Umbrella specification for a set of IETF RFCs
- Aimed at 802.15.4 MAC/PHY devices
- Route-over mesh network (multi-hop)
- Developed primarily for SEP 2.0 (Smart Energy Profile) application layer traffic to aid migration from SEP 1.0
- Certifiable platform
  - PICS and Test Plan

# Status July 2013

- Specification, PICS and test plan complete
  - Approved by ZigBee Alliance in February 2013
  - One or two remaining IDs in the process of becoming RFCs
- Specification Validation Event (SVE) in January 2013
  - 3 golden units
  - 2 compliant platforms

# Implementation

- Can’t give details for commercial reasons
  - 7 independent developers through the process
- Aimed at LWIG class 2 devices
  - ~50 kiB data (RAM), ~250 kiB code (Flash)
  - draft-ietf-lwig-guidance
  - Class 1 devices may be able to act as hosts
  - Some devices have more resources and processing power (e.g. ARM9 core, MiBs RAM/Flash)
- Home-grown OS, embedded Linux

# Next steps for LWIG

- Produce more detailed ID or incorporate in guidance document
  - Aim to start ID or text on completion of SVE
  - Postponed due to my limited availability to work on draft

# Detail on chosen protocols

# Transport layer

- TCP
  - Data plane
    - HTTP
    - HTTPS
- UDP
  - Control plane
    - PANA, MLE
  - Data plane
    - CoAP
      - Not currently proposed for SEP 2.0
      - Maybe used in other application profiles

# Network Layer

- IPv6
  - RFC 2460
  - Not using IPv4
- 6LoWPAN adaptation layer
  - RFC 4944 (IPv6 over 802.15.4)
  - RFC 6282 (header compression)
- Stateless address autoconfiguration (SLAAC)
  - RFC 4862
  - Maps IPv6 addresses to link layer addresses
  - 16 and 64 bit MAC addresses
- 6LoWPAN contexts
  - ULA and/or global prefixes

# Neighbor discovery

- “Classic” ND
  - RFC 4861
  - Not all features used
- 6LoWPAN ND
  - RFC 6775
  - Extends “classic” ND for LLNs and multi-link subnets
- MLE
  - draft-kelsey-intarea-mesh-link-establishment
  - Provides link information for neighbors

# Routing

- RPL
  - RFC 6550
  - Route-over
  - Intermediate routers as well as border router
  - Based on Directed Acyclic Graph (DAG)
- MRHOF objective function
  - RFC 6719
- Trickle multicast
  - draft-ietf-roll-trickle-mcast

# Security (1)

- Link layer security
  - 802.15.4 frame security (AES-CCM)
  - Global network key
- PANA (EAP transport)
  - RFC 5191 (PANA)
  - RFC 6345 (PANA relay)
  - RFC 6786 (encryption AVP)
  - Carries EAP in UDP datagrams
  - Convenient for 6LoWPAN header compression

# Security (2)

- EAP-TLS (EAP method)
  - RFC 5216
  - Carries TLS records for authentication and key establishment
- TLS cipher suites
  - RFC 5487 (pre-shared key with AES-CCM)
    - c/w Wi-Fi WPA/WPA2 PSK passphrase
  - draft-mcgrew-tls-aes-ccm-ecc-05 (elliptic curve DH and ECDSA with AES-CCM)
    - In conjunction with device certificate
    - Also used in SEP 2.0

# Additional IETF protocols developed specifically for ZigBee IP

- MLE (Mesh Link Establishment)
  - Transfer of link costs between neighbors
    - Improved link costs for RPL metrics
  - Transfer of frame counters between neighbors
    - Freshness checking and nonce consistency
  - Dissemination of network-wide information, e.g. beacon payload, PAN ID, channel
- PANA relay
  - Enables PANA for multihop networks
- PANA encryption extensions
  - Secure delivery of configuration parameters

# Restrictions to meet resource constraints

- 6LoWPAN – 4 contexts plus stateless (64-bit and 16-bit address)
- RPL – non-storing mode
  - Resources required mainly at DAG root
  - Source routing down the DAG
- TLS – only two cipher suites
  - Pre-shared key
  - Elliptic curve for processing speed up and memory saving
- Buffer restrictions for pending data to sleeping hosts

# Other implementation efficiencies

- Holistic approach to combining protocols
- AES-CCM used universally at many layers
- RPL, ND, MAC all have concepts of neighbors and stored addresses
- Limit the storage by linking tables from different protocols together
- Cross-layer management – more complex API whereby all protocols have access to other data and can use it accordingly