IPv6 over IEEE 802.15.4 (6LoWPAN)

Geoff Mulligan
Chair of 6LoWPAN WG
Chair Zigbee IPv6 Task Group
Invensys Controls

Overview of LoWPAN

- A simple low throughput wireless network comprising typically low cost and low power devices
- Devices in the network may work together to connect the physical environment to real world applications, e.g., wireless sensors networks
- Devices may also act as simple controls such as a remote control for a home
- Common topologies include – star, mesh, and combinations of star and mesh
- The Phy and MAC layers *conform* to IEEE 802.15.4-2003 standard

802.15.4 MAC

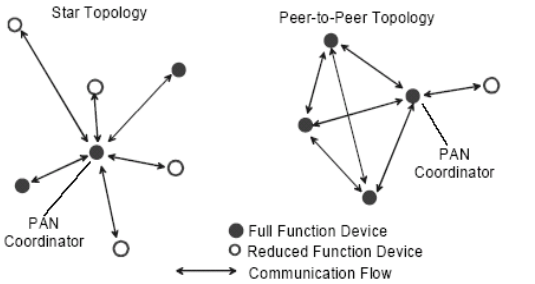


Figure 1—Star and peer-to-peer topology examples

Octets: 2	1	0/2	0/2/8	0/2	0/2/8	variable	2
Frame control	Sequence number	Destination PAN identifier	Destination address	Source PAN identifier	Source address	Frame payload	FCS
		Addressing fields					
MHR						MAC payload	MFR

Figure 34—General MAC frame format

- Unslotted or Slotted CSMA/CA
- Supports low power operation
- Supports AES for security
- MAC Frame size - 127 octets
- Frame payload size – 102 octets
- Provides peer-to-peer communication
- Can support higher layer mesh networks

Challenges of LoWPAN

Impact Analysis	Addressing	Routing	Security	Network management
Low power (1-2 years lifetime on batteries)	Storage limitations, low overhead	Periodic sleep aware routing, low overhead	Simplicity (CPU usage), low overhead	Periodic sleep aware management, low overhead
Low cost (<$10/unit)	Stateless address generation	Small or no routing tables	Ease of Use, simple bootstrapping	Space constraints
Low bandwidth (<300kbps)	Compressed addresses	Low routing overhead	Low packet overhead	Low network overhead
High density (<1-2 units/sq meter)	Large address space – IPv6	Scalable and routable to *a node*	Robust	Easy to use and scalable
IP network interaction	Address routable from IP world	Seamless IP routing	Work end to end from IP network	Compatible with SNMP, etc

Goals of 6LoWPAN

- Specify methods to do IPv6 stateless address auto configuration
- Specify/use header compression schemes.
- Specify implementation considerations and best methods of an IPv6 stack
- Define adaptation (frag/reassembly) layer to match IPv6 MTU requirements
- Methods for meshing on LoWPAN below IP

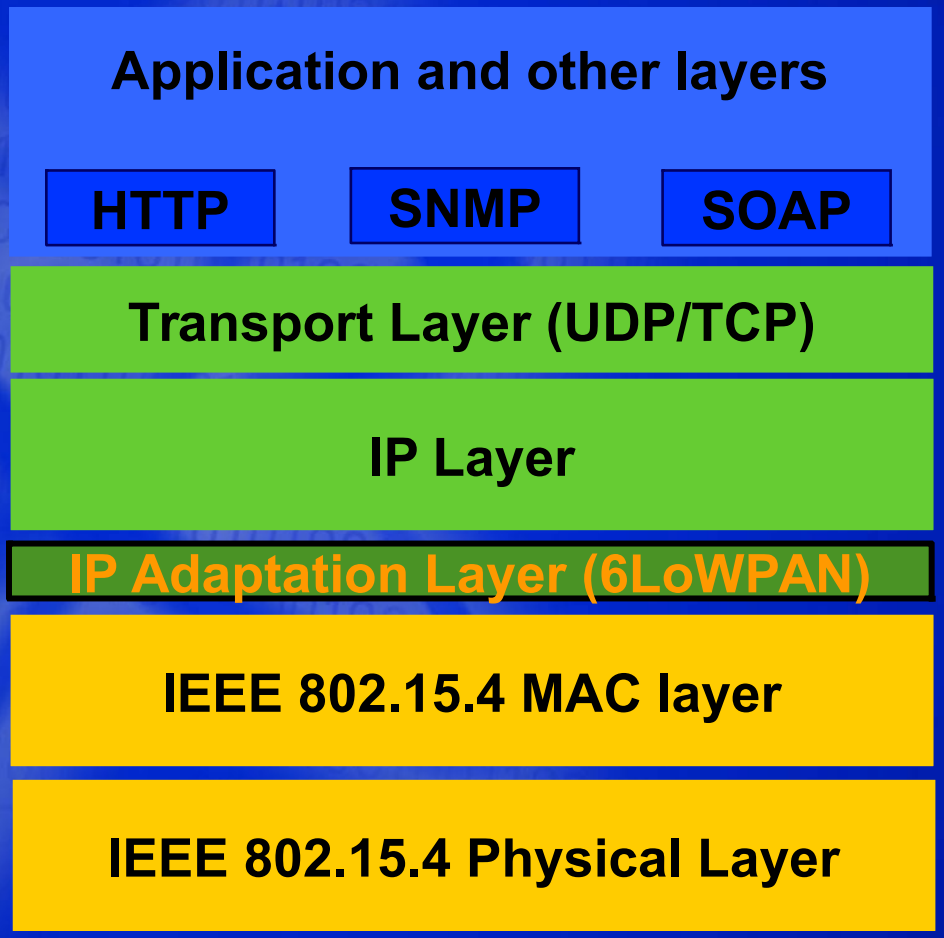
Not currently in charter (but interest within the group)

- Use/adapt network management technologies for LoWPANs
- Specify new protocols for device discovery mechanisms
- Document LoWPAN security threats
- IPv4 over 802.15.4

Assumptions

- Devices conform to IEEE 802.15.4-2003 standard
- Devices “typically” send small amounts of data
- Typically “constrained” devices (computing, power, cost, memory, etc)

6LoWPAN Architecture



6LoWPAN –

- IPv6 over 802.15.4
- Defines Adaptation layer
- Allows large packet transmission
- Allows packet delivery in a mesh
- Allows protocol multiplexing
- Provides transparency to IP layer and above
- Best case, IPv6 header compressed to 2 octets

Why use a standard

- Proprietary solutions chosen for performance characteristics
- Standards perceived to be less optimized

Reality:

"Within 12 months technology will overcome performance gains by proprietary systems."

Key value drivers for IP over LoWPAN

- Most of the IP based technologies already exist, well known and proven to be working
  - Recently shown as workable in wireless environments
- The pervasive nature of IP networks allows use of existing infrastructure
  - Enables key applications in home automation where IP is pervasive
- No need to invent new technologies when IP can easily ride over 802.15.4
- IPR for IP networking technology is either more favorable or at least better understood than proprietary and newer solutions

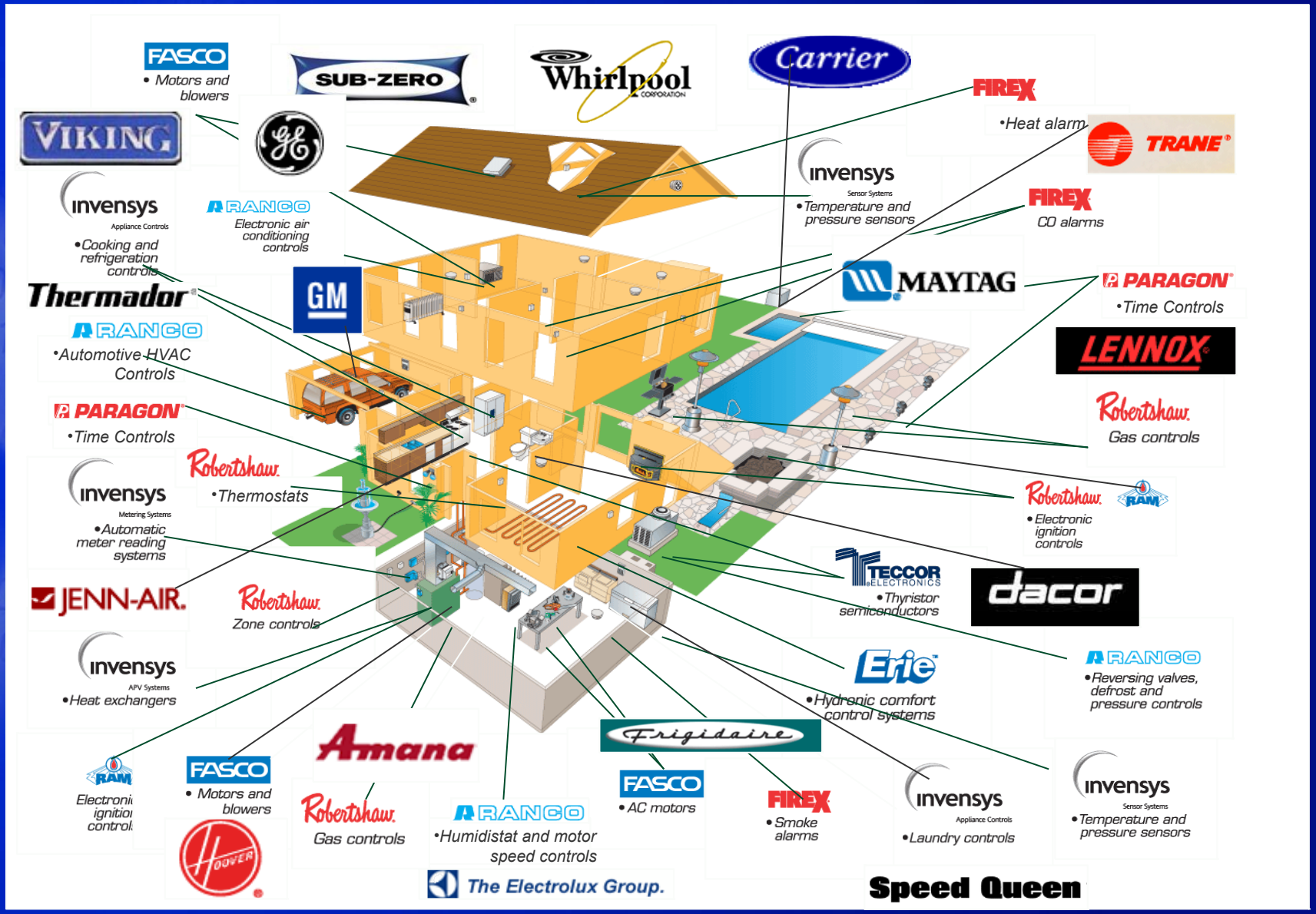
Zigbee and the IETF

- IETF WG anticipates studying newly released Zigbee specification
- Zigbee Study Group investigating support of IP on Zigbee stack
- Should not be an “either/or”

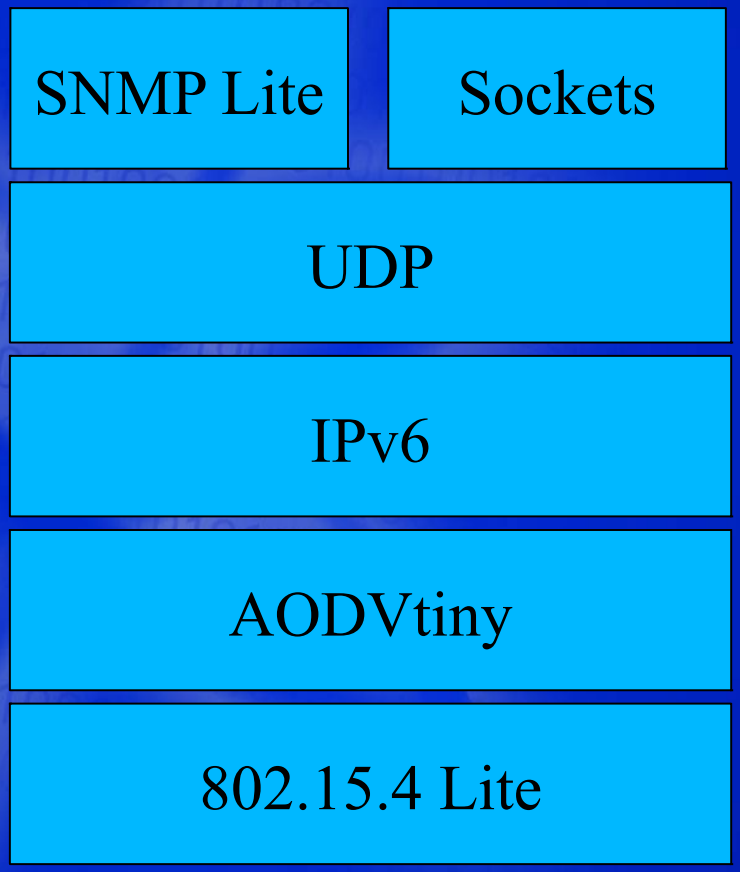
Current status

- 6LoWPAN became an official WG within IETF
- More than 50 company participation (Intel, Invensys, Microsoft, Sun, Nokia, Whirlpool, Danfoss, Samsung, Helicomm, etc)
- Draft-ietf-lowpan-goals-assumptions-00.txt submitted to IETF and available for review (http://www.ietf.org/internet-drafts/draft-kushalnagar-lowpan-goals-assumptions-00.txt)
- Draft-ietf-lowpan-ipv6-over-802.15.4-02.txt submitted to IETF and available for review (http://www.ietf.org/internet-drafts/draft-montenegro-lowpan-ipv6-over-802.15.4-02.txt)
- Active changes undergoing within various drafts

Invensys Residential POPs



Invensys IPv6 Stack today



- Range: > 100m
- Reliable and self healing network
- Battery life: > 1 year using AA
- Network of PANs
- Low Cost: < $10 now; < $5 2006
- Stack: < 15K code size

Goodwatts

- Energy Management (monitoring and control)
- Previously proprietary RF network
- Deploying IPv6 over 802.15.4 mesh sensor network
- Pilots projects:
  - California, Oregon, Nevada, Pennsylvania, Canada

IETF Participation

- IETF meets 3 times per year.
- Next meeting in Paris – 31 July
- Web:

  http://www.ietf.org
- To subscribe to WG mailing list:

  6lowpan-request@lists.ietf.org

Contact information

- **Geoff Mulligan**

geoff.mulligan@invensys.com