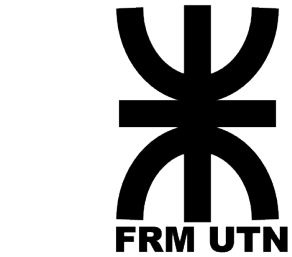

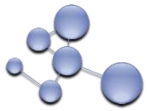

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9º Foro Latinoamericano de IPv6 – FLIP6

Cancún MX - 15 al 20 de mayo de 2011

6LoWPAN
IPv6 for Wireless Sensor Network

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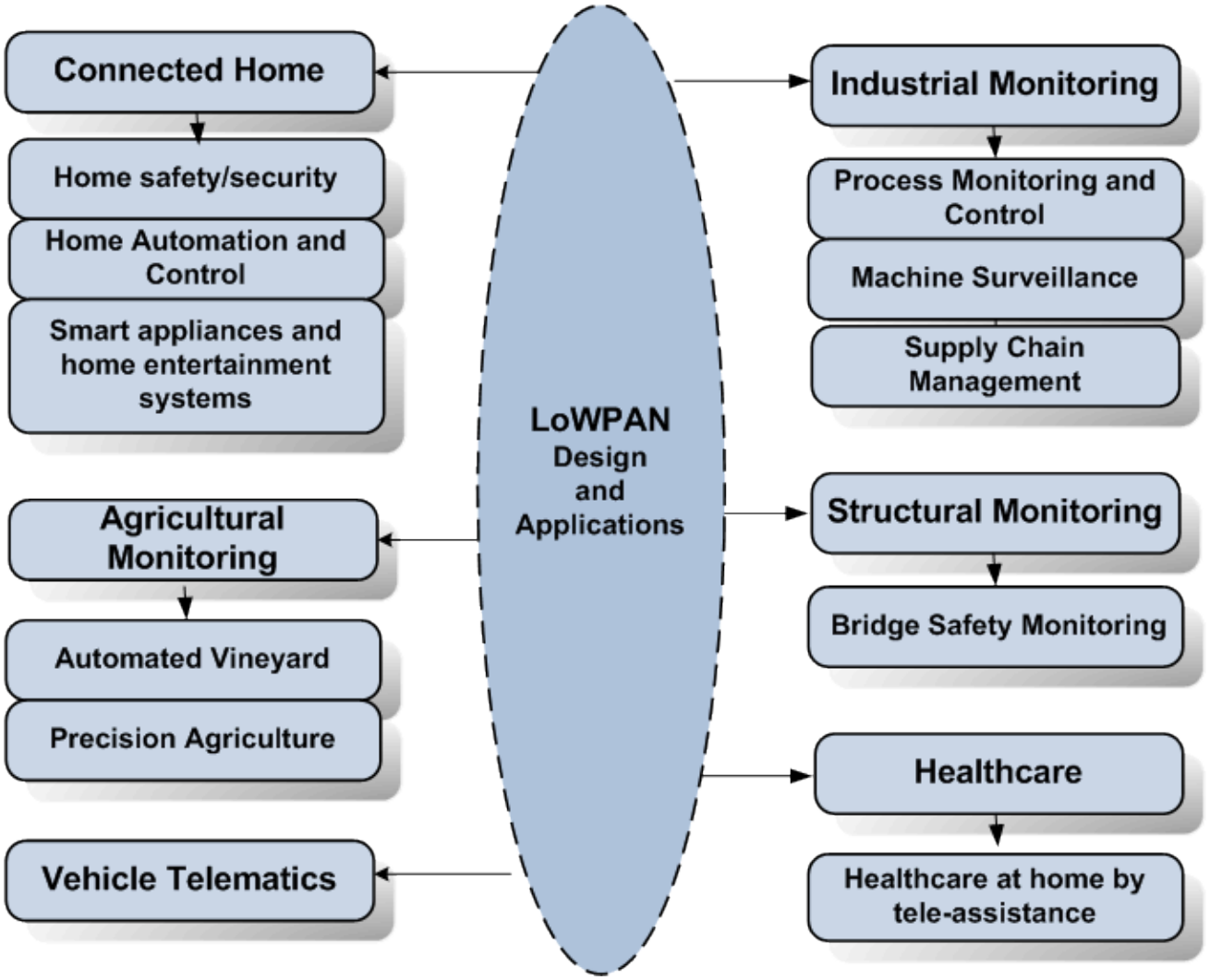
- G. Montenegro,N. Kushalnagar,J. Hui, D. Culler “Transmission of IPv6 Packets over IEEE 802.15.4 Networks”, RFC 4944, September 2007, IETF

- Shelby & Bormann, “The Wireless Embedded Internet” ISBN: 978-0-470-74799-5, (c) 2009 John Wiley & Sons Ltd

- David E. Culler & Jonathan Hui ”6LoWPAN Tutorial: IP on IEEE 802.15.4 Low-Power Wireless Networks”, Arch Rock Corporation
- “Compression Format for IPv6 Datagrams in 6LoWPAN Networks” draft-ietf-6lowpan-hc-13.
- “Neighbor Discovery Optimization for Low-power and Lossy Networks” draft-ietf-6lowpan-nd-15
- “Design and Application Spaces for 6LoWPANs”, draft-ietf-6lowpan-usecases-09.

Internet of Things

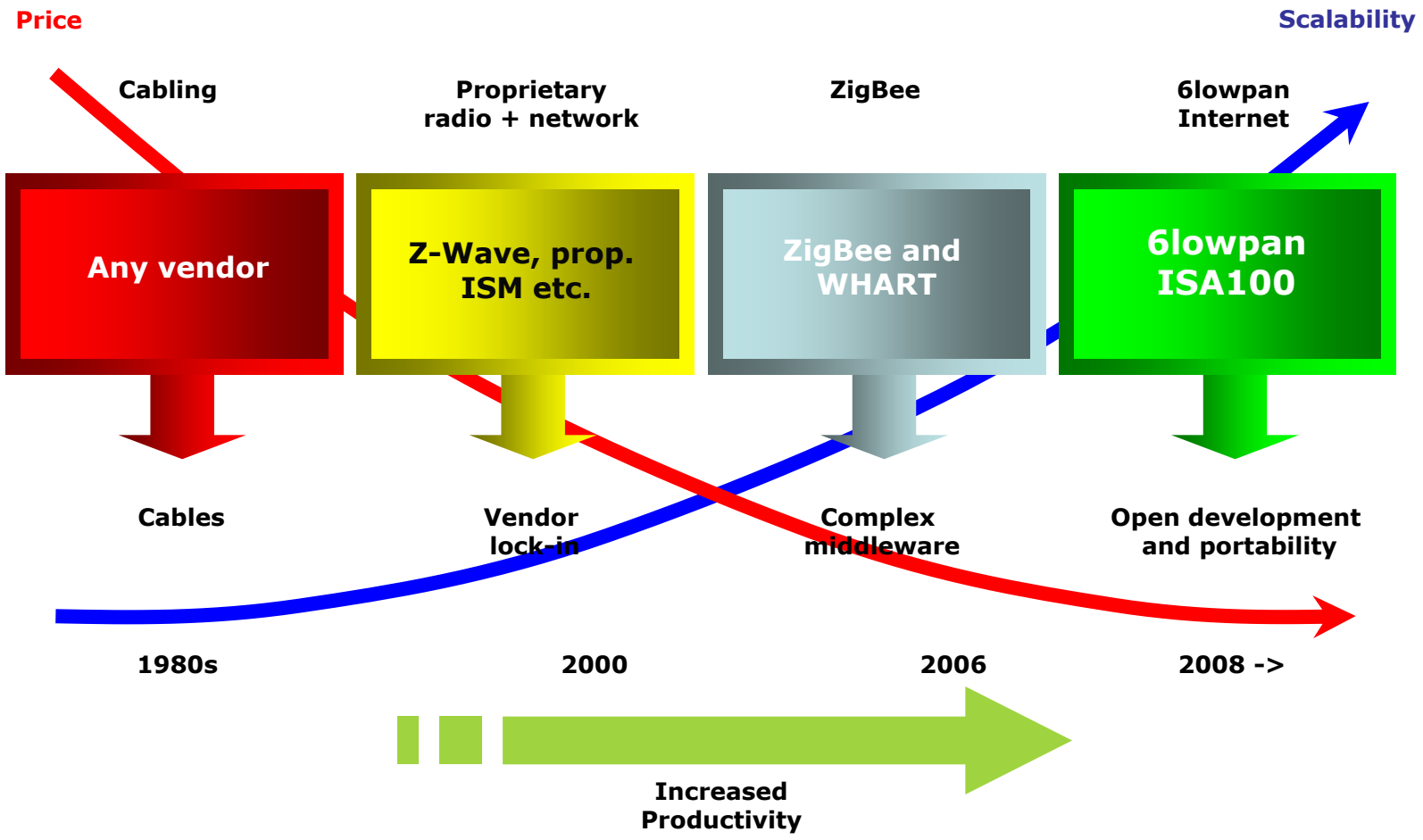


Benefits of 6LoWPAN Technology

IPv6 over Low-Power Wireless Personal Area Networks

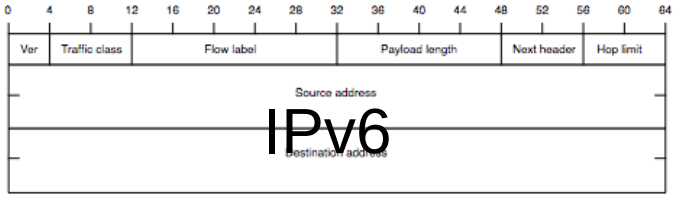
- Low-power RF + IPv6 =
  The Wireless Embedded Internet
- 6LoWPAN makes this possible
- The benefits of 6LoWPAN include:
  - Open, long-lived, reliable **standards**
  - **Easy** learning-curve
  - Transparent **Internet** integration
  - Network **maintainability**
  - Global **scalability**
  - **End-to-end** data flows

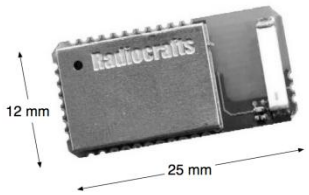
Evolution of Wireless Sensor Networks



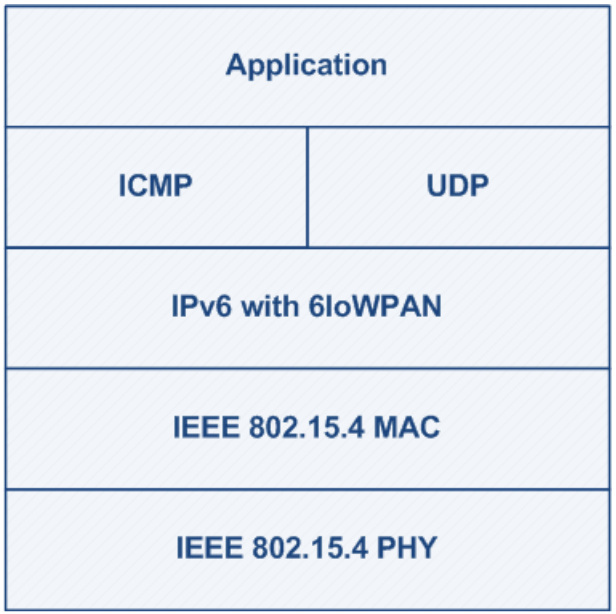
What is 6LoWPAN?

- IPv6 over Low-Power wireless Area Networks
- Defined by IETF standards
  - RFC 4919, 4944
  - draft-ietf-6lowpan-hc and -nd
  - draft-ietf-roll-rpl
- Stateless header compression
- Enables a standard socket API
- Minimal use of code and memory
- Direct end-to-end Internet integration
  - Multiple topology options





Protocol Stack

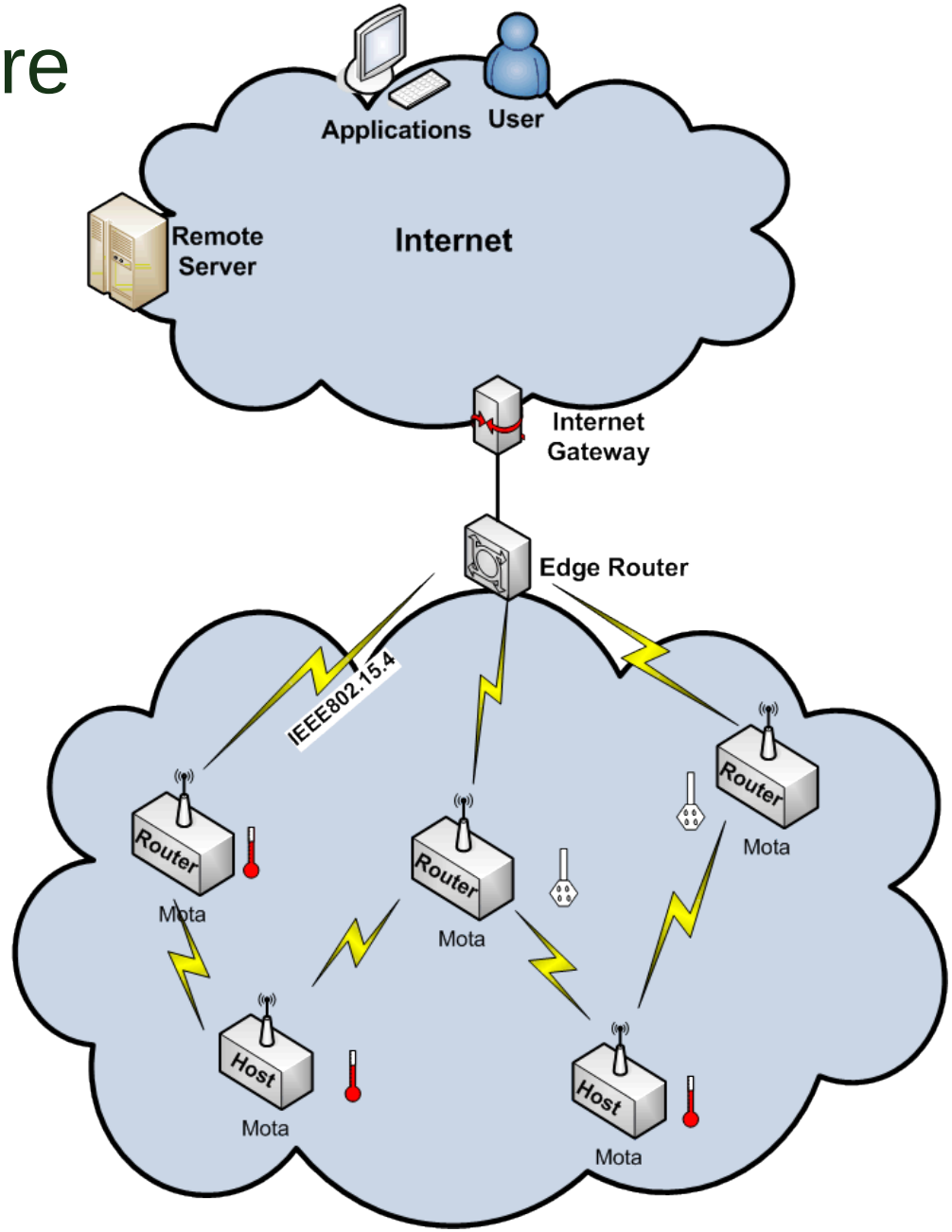


6loWPAN Protocol Stack

Features

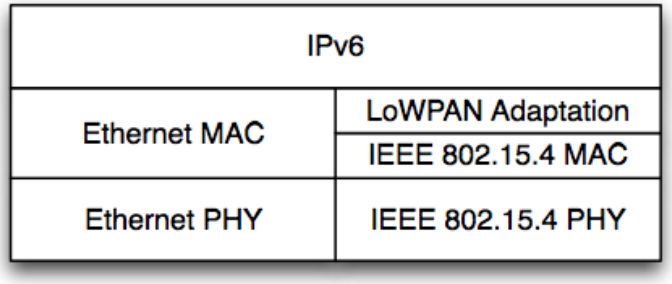
- Support for e.g. 64-bit and 16-bit 802.15.4 addressing
- Useful with low-power link layers such as IEEE 802.15.4, narrowband ISM and power-line communications
- Efficient header compression
  - IPv6 base and extension headers, UDP header
- Network autoconfiguration using neighbor discovery
- Unicast, multicast and broadcast support
  - Multicast is compressed and mapped to broadcast
- Fragmentation
  - 1280 byte IPv6 MTU -> 127 byte 802.15.4 frames
- Support for IP routing (e.g. IETF RPL)
- Support for use of link-layer mesh (e.g. 802.15.5)

Architecture



Architecture

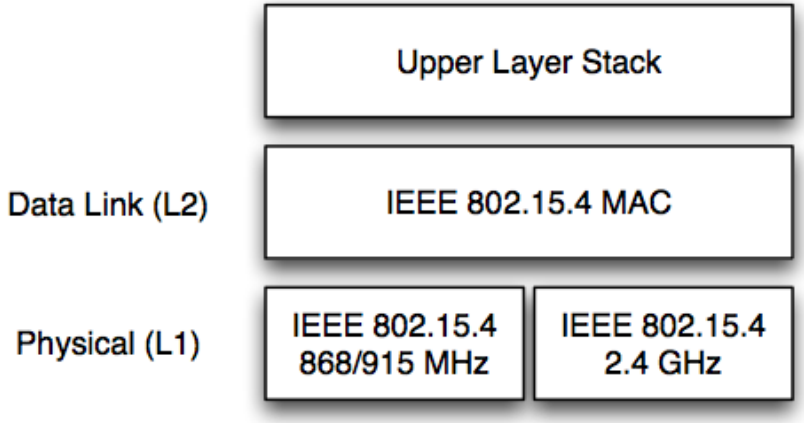
- LoWPANs are stub networks
- Simple LoWPAN
  - Single Edge Router
- Extended LoWPAN
  - Multiple Edge Routers with common backbone link
- Ad-hoc LoWPAN
  - No route outside the LoWPAN
- Internet Integration issues
  - Maximum transmission unit
  - Application protocols
  - IPv4 interconnectivity
  - Firewalls and NATs
  - Security



IPv6-LoWPAN Router Stack

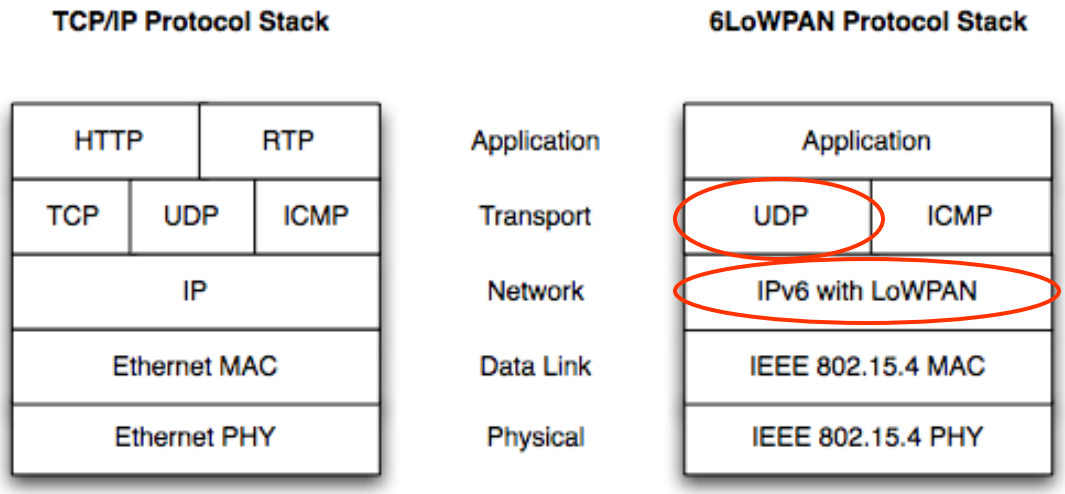
IEEE 802.15.4

- Important standard for home networking, industrial control and building automation
- Three PHY modes
  - 20 kbps at 868 MHz
  - 40 kbps at 915 MHz
  - 250 kbps at 2.4 GHz (DSSS)
- Beaconless mode
  - Simple CSMA algorithm
- Beacon mode with superframe
  - Hybrid TDMA-CSMA algorithm
- Up to 64k nodes with 16-bit addresses
- Extensions to the standard
  - IEEE 802.15.4a, 802.15.4e, 802.15.5



The 6LoWPAN Format

- 6LoWPAN is an adaptation header format
  - Enables the use of IPv6 over low-power wireless links
  - IPv6 header compression
  - UDP header compression
- Format initially defined in RFC4944
- Updated by draft-ietf-6lowpan-hc (work in progress)

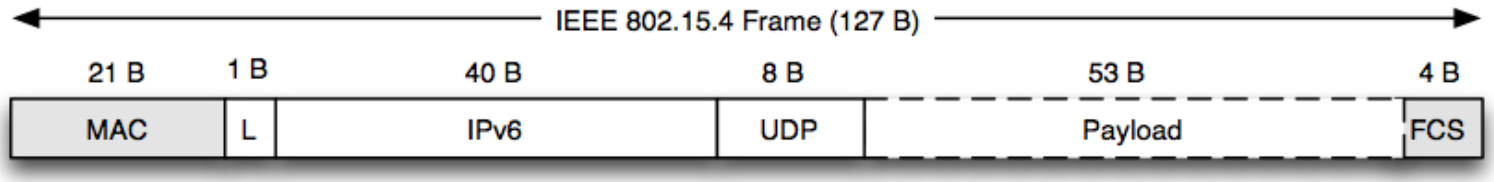


The 6LoWPAN Format

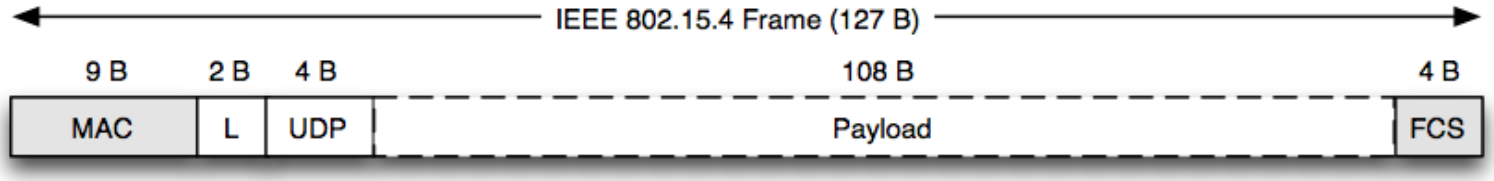
- 6LoWPAN makes use of IPv6 address compression
- RFC4944 Features:
  - Basic LoWPAN header format
  - HC1 (IPv6 header) and HC2 (UDP header) compression formats
  - Fragmentation & reassembly
  - Mesh header feature (depreciation planned)
  - Multicast mapping to 16-bit address space
- draft-ietf-6lowpan-hc Features:
  - New HC (IPv6 header) and NHC (Next-header) compression
  - Support for global address compression (with contexts)
  - Support for IPv6 option header compression
  - Support for compact multicast address compression

6LoWPAN Headers

- Orthogonal header format for efficiency
- Stateless header compression



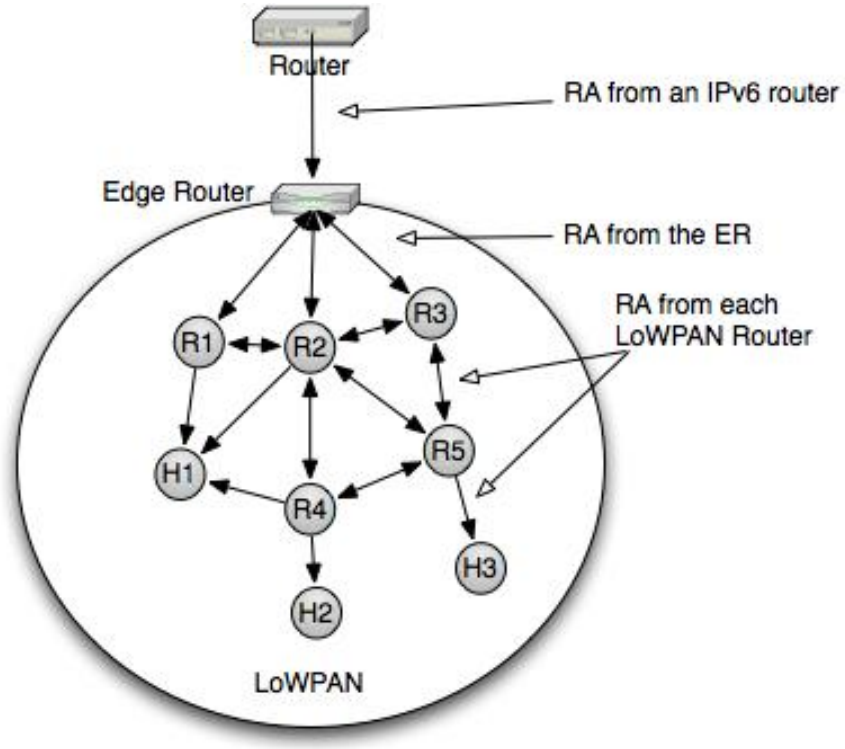
Full UDP/IPv6 (64-bit addressing)



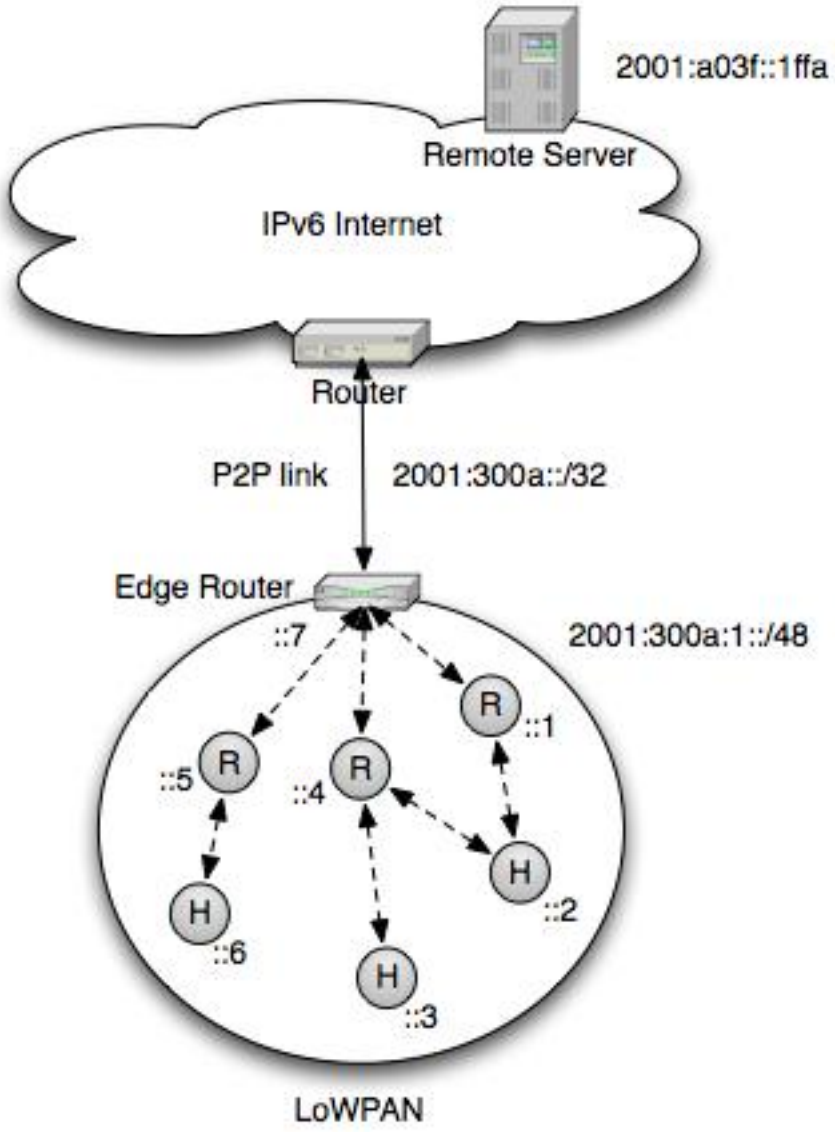
Minimal UDP/6LoWPAN (16-bit addressing)

Prefix Dissemination

- In normal IPv6 networks RAs are sent to a link based on the information (prefix etc.) configured for that router interface
- In ND for 6LoWPAN RAs are also used to automatically disseminate router information across multiple hops

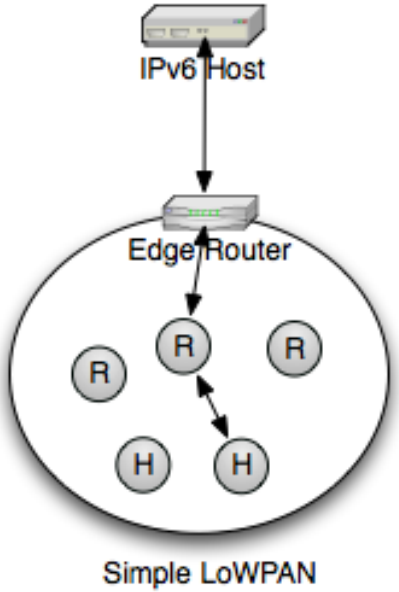


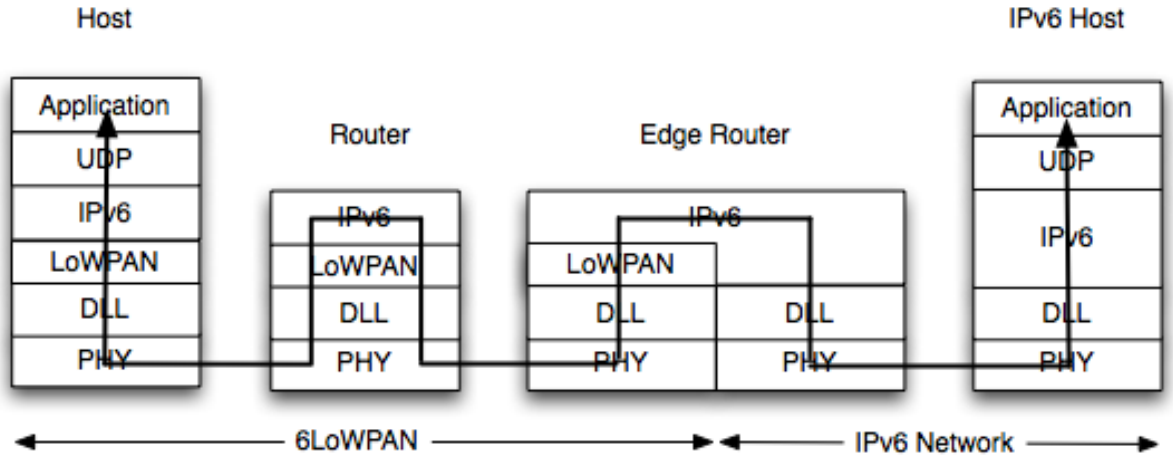
Addressing Example



6LoWPAN Routing

- Here we consider IP routing (at layer 3)
- Routing in a LoWPAN
  - Single-interface routing
  - Flat address space (exact-match)
  - Stub network (no transit routing)





IETF ROLL

- Routing Over Low power and Lossy networks (ROLL)
  - Working group at the IETF
- Standardizing a routing algorithm for embedded apps
- Application specific requirements
  - Home automation
  - Commercial building automation
  - Industrial automation
  - Urban environments
- Analyzed all existing protocols
- Solution must work over IPv6 and 6LoWPAN
- Protocol in-progress called RPL “Ripple”
  - Proactive distance-vector approach
  - See draft-ietf-roll-rpl for detailed information

Protocols Stacks

- **Contiki**
  - Low-Power IPv6/RPL Network
- **Tiny OS**
  - BLIP, the Berkeley Low-power IP stack
  - IPv6 Ready
- **Nano Stack** (Sensinode)
  - Nano Stack, Nano Router, Nano Service
  - Nano Sensor
- **Jennic 6LoWPAN** (Jennic)
  - JN5139 Wireless Microcontroller
  - Jenie API, SNAP, JenNet

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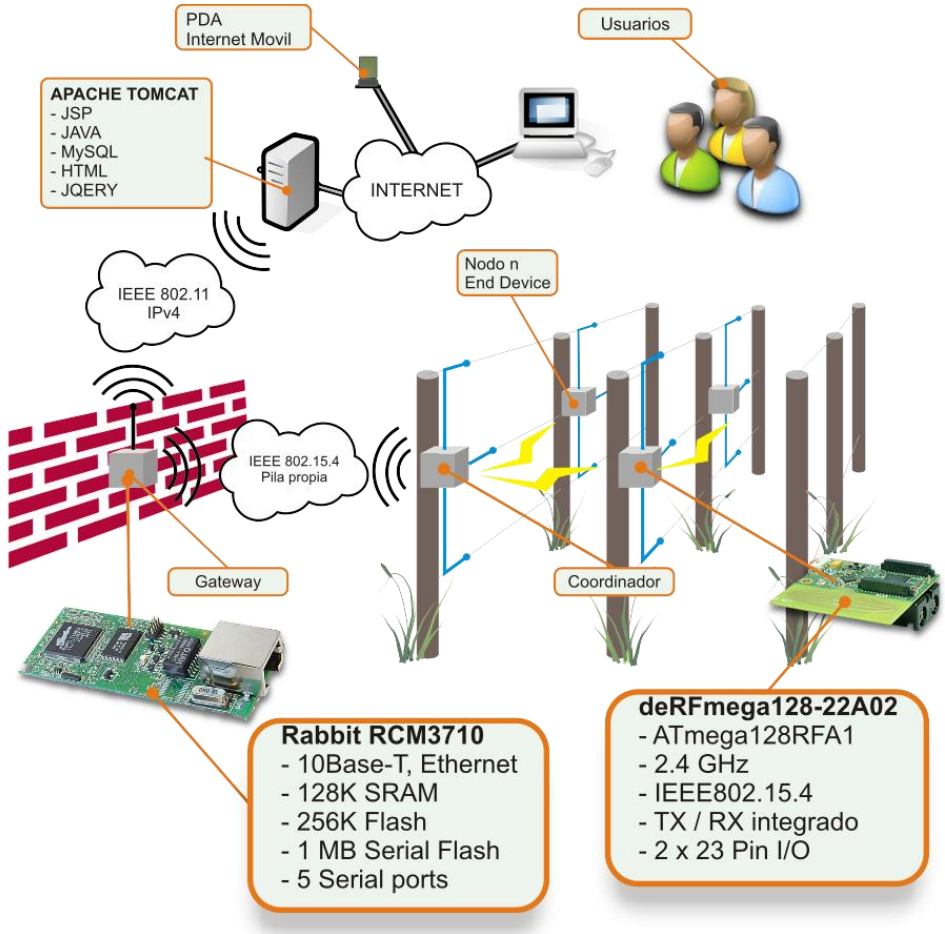
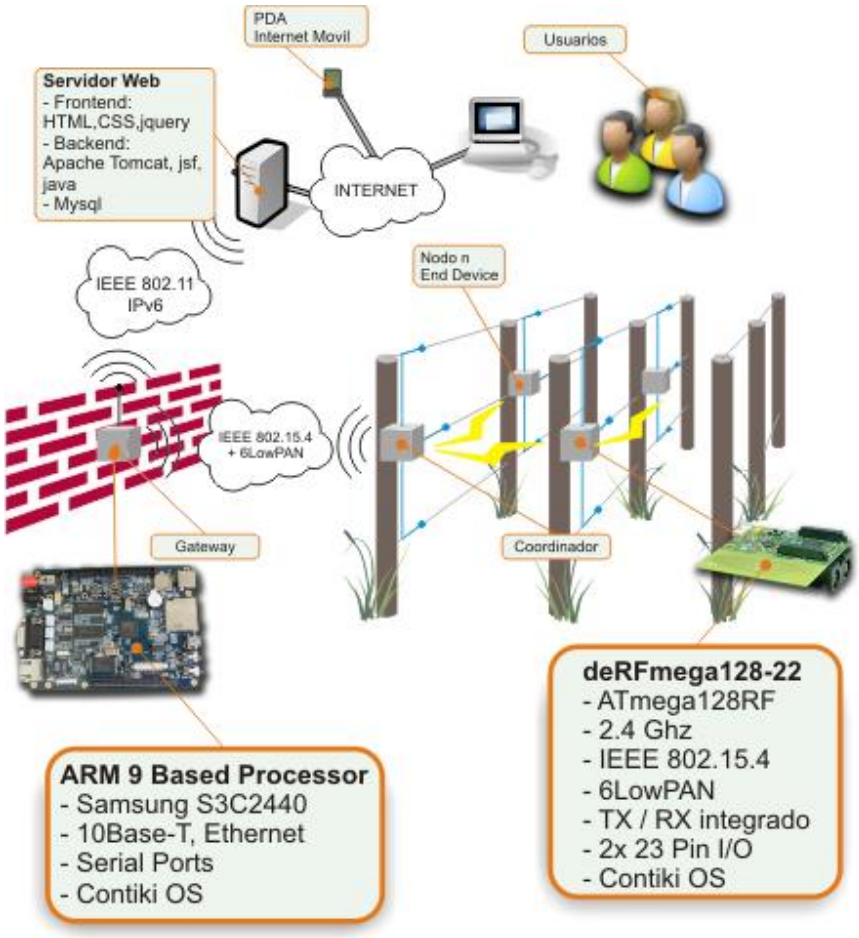
SIPIA Net

Wireless Sensor Network for Agronomical Research

grid TICs
Grupo UTN de I&D
Tecnologías de la Información y Comunicaciones
www.gridtics.frm.utn.edu.ar



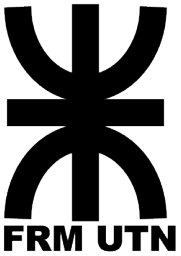


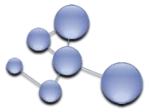
SIPIA Net

Propietary STACK (gridTiCS)

SIPIA6 Net

6loWPAN STACK





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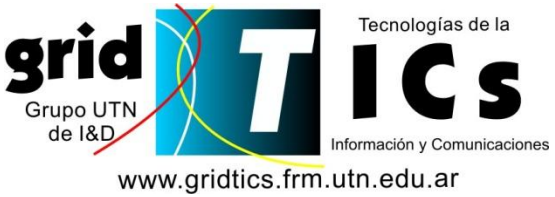

Credits

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Francisco González - Principal Investigator - FCA - UNCUYO

Sebastian Tromer - Net Architecture– WSNGroup - gridTICs

Ana Diedrichs – Web Applications – WSNGroup - gridTICs

German Tabacchi - Edge Router – WSNGroup - gridTICs

Matias Pecchia - Edge Router - WSNGroup - gridTICs

Pablo Miralles - 6loWPAN - WSNGroup - gridTICs

Cristian Panella - 6loWPAN - WSNGroup – gridTICs