

Internet of Things

Clément **DUHART**

Dr - Computer Science

clement.duhart@devinci.fr



01|

Internet of Things

02|

Contiki OS

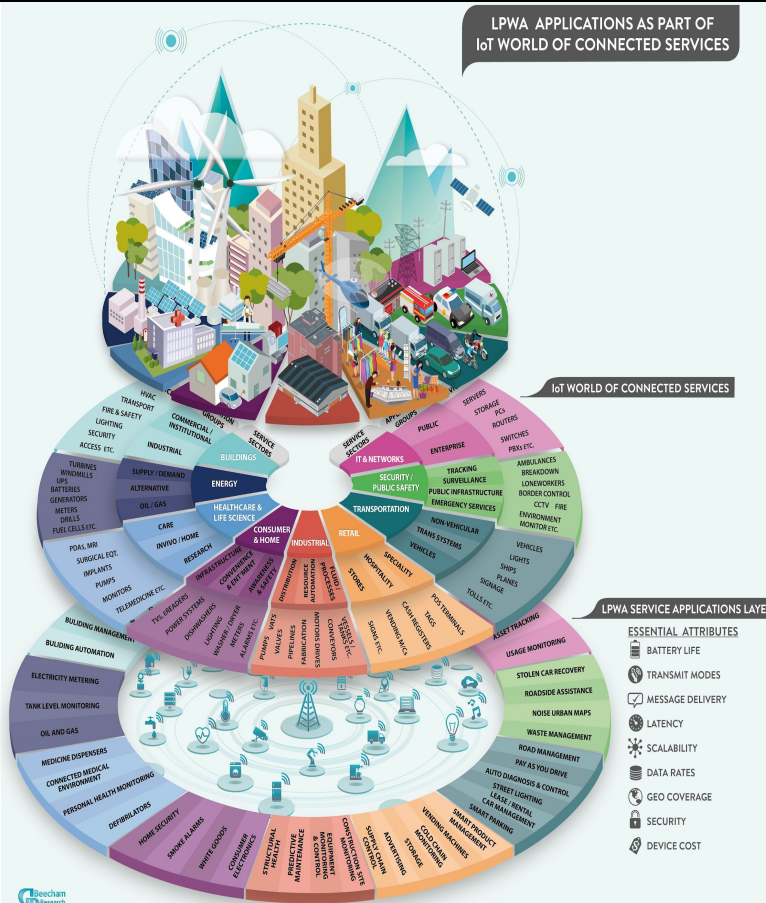
03|

6LoWPAN

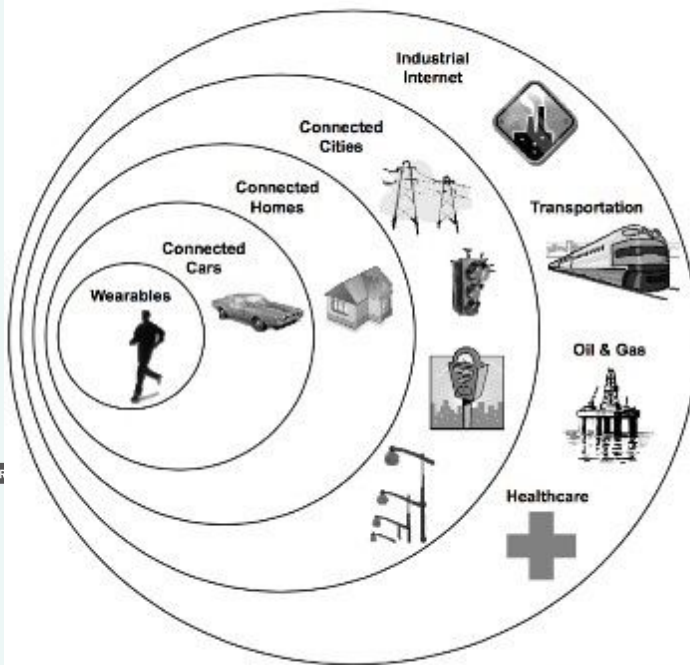
04|

Assignment

01| Internet of Things



The IoT landscape - One size doesn't fit all



Broad variety of wireless standards, industry bodies, technologies for different types of networks:

- Body Area Network (BAN)
- Body Sensor Network (BSN)
- Medical Body Area Network (MBAN)
- Personal Area Network (PAN)
- Home Area Network (HAN)
- Nearby Area Network (NAN)
- Local Area Network (LAN)
- Wide Area Network (WAN)
- Global Area Network (GAN)

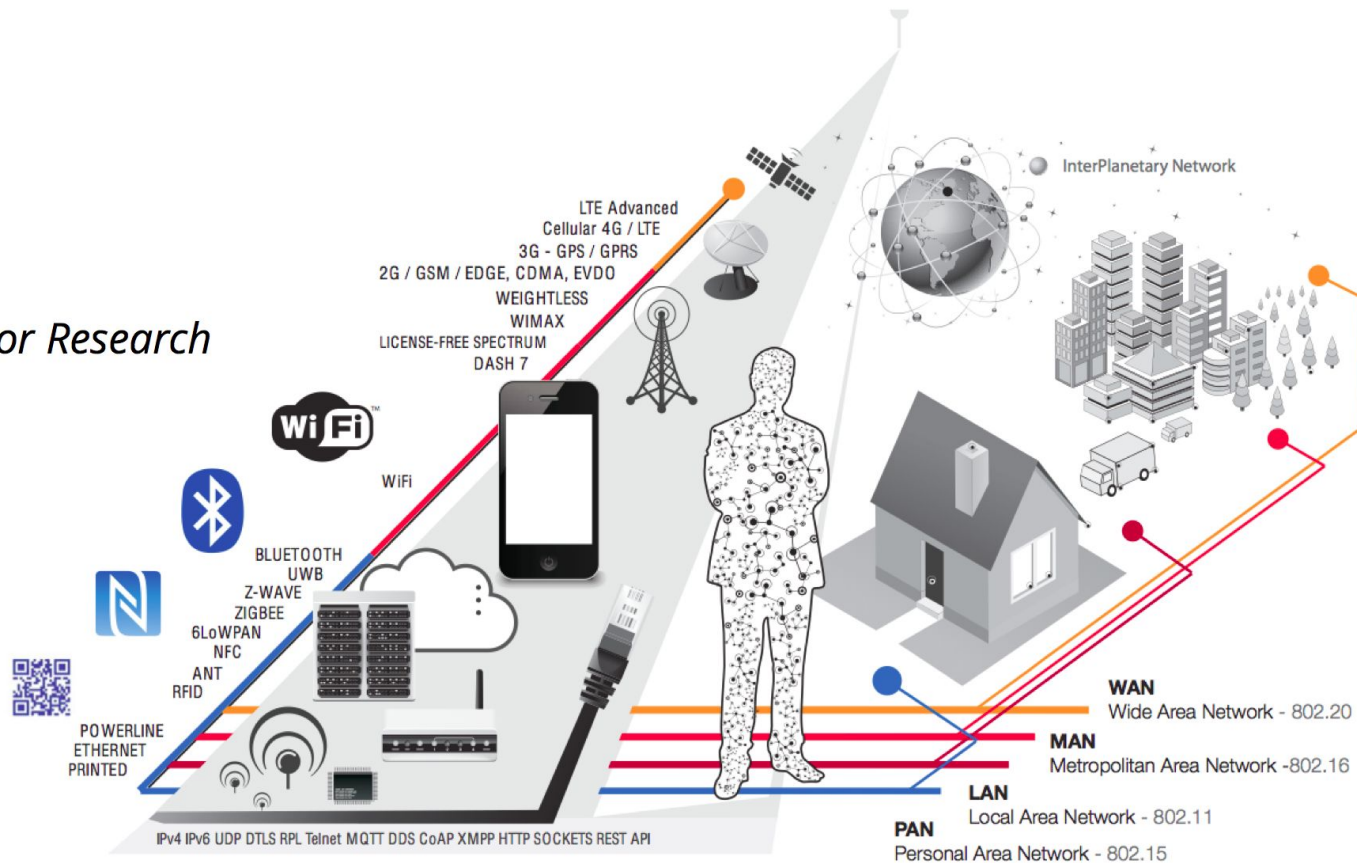
Source: Goldman Sachs, IoT Primer, September 3, 2014; [Internet of Things: Making sense of the next mega-trend](#)

01| Internet of Things

Réseaux et protocoles

Crédits : Postscapes et Harbor Research

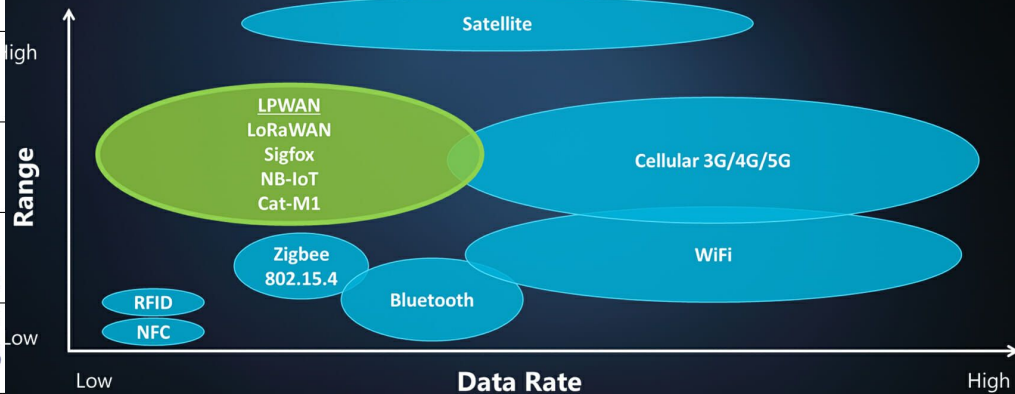
(CC BY-NC-ND 4.0)



01| Internet of Things

	TCP/IP Support	Gateway Needed?	Power	Data Rate	Topology	Wireless Spectrum	Alliance	Module Costs (5K EAU)	Other
Ethernet	Over 802.3	No, directly wired to Internet	High / Power-over-Ethernet (PoE) 802.3af	Up to 1 Gbps	Varies	None	None	\$10 +	RJ45
Wi-Fi	Over 802.11	No, connects to Internet through Wi-Fi access points and routers	High (low-power modules available for battery applications)	1-135 Mbps	None	2.4 GHz, 5 GHz	Wi-Fi Alliance	< \$10 +	Internal or external antenna
6LoWPAN	Over 802.15.4	Yes	Low	0.04-0.25 Mbps	Varies	868-921 MHz, 2.4 GHz	Internet Engineering Task Force (IETF)	\$5 +	Internal or external antenna
ZigBee	Lacks native TCP/IP support, based on 802.15.4	Yes, ZigBee Coordinator	Low	0.04-0.25 Mbps	Mesh	868-921 MHz, 2.4 GHz	ZigBee Alliance	< \$4 +	Internal or external antenna
Z-Wave	Lacks native TCP/IP support, based on Z-Wave standard	Yes	Low	0.1 Mbps, primarily for remote control	Mesh	868-921 MHz	Z-Wave Alliance	\$5 +	Internal or external antenna, managed by Sigma Designs
Bluetooth	Lacks native TCP/IP support, based on Bluetooth standard	Yes	Moderate	0.7-2.1 Mbps	Point-to-point	2.4 GHz	Bluetooth Special Interest Group (SIG)	\$5 +	Pairing can be complicated, max 8 devices in piconet, ~100 ms latency
Bluetooth Smart (such as BLE, BT 4.0)	Lacks native TCP/IP support, based on Bluetooth LE standard	Yes	Low to moderate	0.27 Mbps maximum	Point-to-point	2.4 GHz	Bluetooth Special Interest Group (SIG)	\$5 +	Simpler to pair devices, new version 4.2 connects directly with Internet
Cellular	TCP/IP over cellular network	No, connects to Internet/cloud through cellular service provider network	High	Varies based on technology	Point-to-point	Varies	None	Monthly service charges, modules, carrier certification fees	External Antenna Only, Monthly Service

The attributes of different wireless and LPWAN (Low-Power WAN) technologies



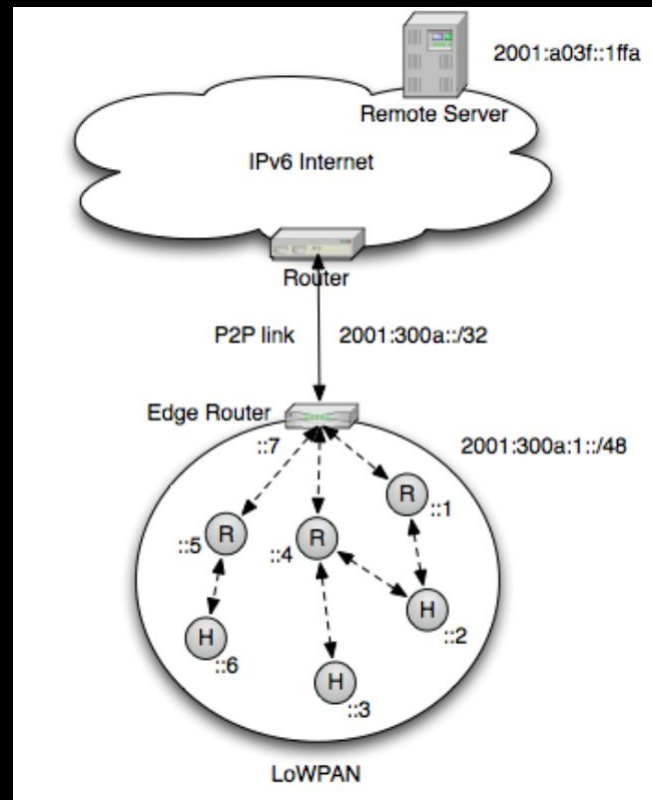
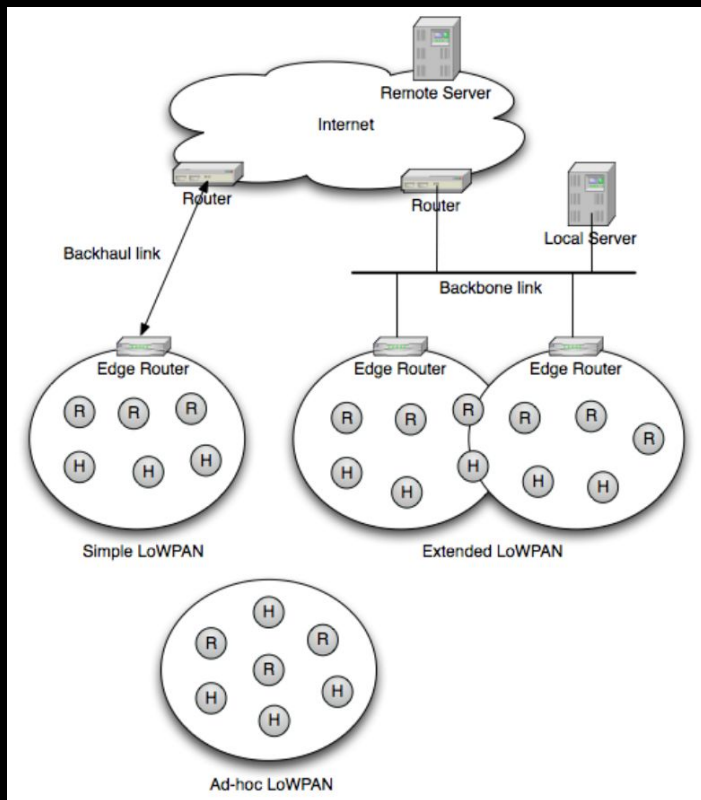
The low-power, extended-range capabilities of LoRaWAN (Long-Range WAN) show why the technology is perfectly suited to IoT applications where low power, low data-rates and extended range is a valued. LoRaWAN is far more power efficient than WiFi and 4G, allowing devices to run on battery for years.



021

IPV6 for Low Power Wireless Personal Area Network

01| Wireless Personal Area Networks



01| Wireless Personal Area Networks

An IPv4 address (dotted-decimal notation)

172 . 16 . 254 . 1

↓ ↓ ↓ ↓
10101100.00010000.11111110.00000001

One byte=Eight bits

Thirty-two bits (4 * 8), or 4 bytes

An IPv6 address (in hexadecimal)

2001:0DB8:AC10:FE01:0000:0000:0000:0000

↓ ↓ ↓ ↓
2001:0DB8:AC10:FE01:: Zeroes can be omitted

10000000000001:0000110110111000:1010110000010000:1111111000000001:
0000000000000000:0000000000000000:0000000000000000:0000000000000000

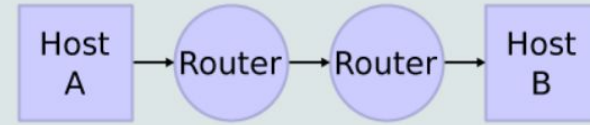
An IPv6 address (in hexadecimal)

2001:0DB8:AC10:FE01:0000:0000:0000:0000

↓ ↓ ↓ ↓
2001:0DB8:AC10:FE01:: Zeroes can be omitted

10000000000001:0000110110111000:1010110000010000:1111111000000001:
0000000000000000:0000000000000000:0000000000000000:0000000000000000

Network Connections



Stack Connections

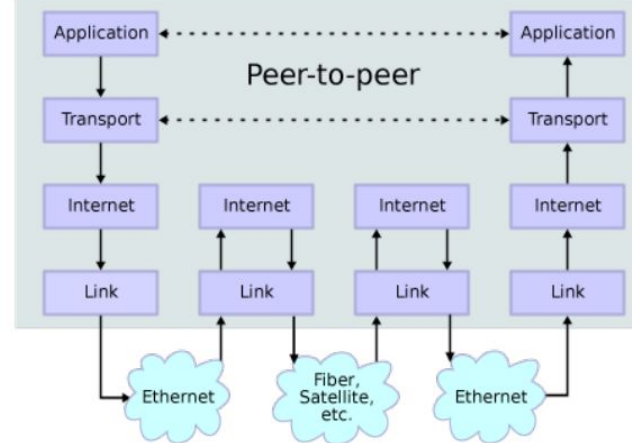


Image source: (Wikipedia) [GFDL](#)

02| 6LoWPAN : IPV6 Low Power Wireless Personal Network

- **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)**

02| Wireless Sensor Networks

TCP/IP Protocol Stack

HTTP		RTP	
TCP	UDP	ICMP	
IP			
Ethernet MAC			
Ethernet PHY			

Application

Transport

Network

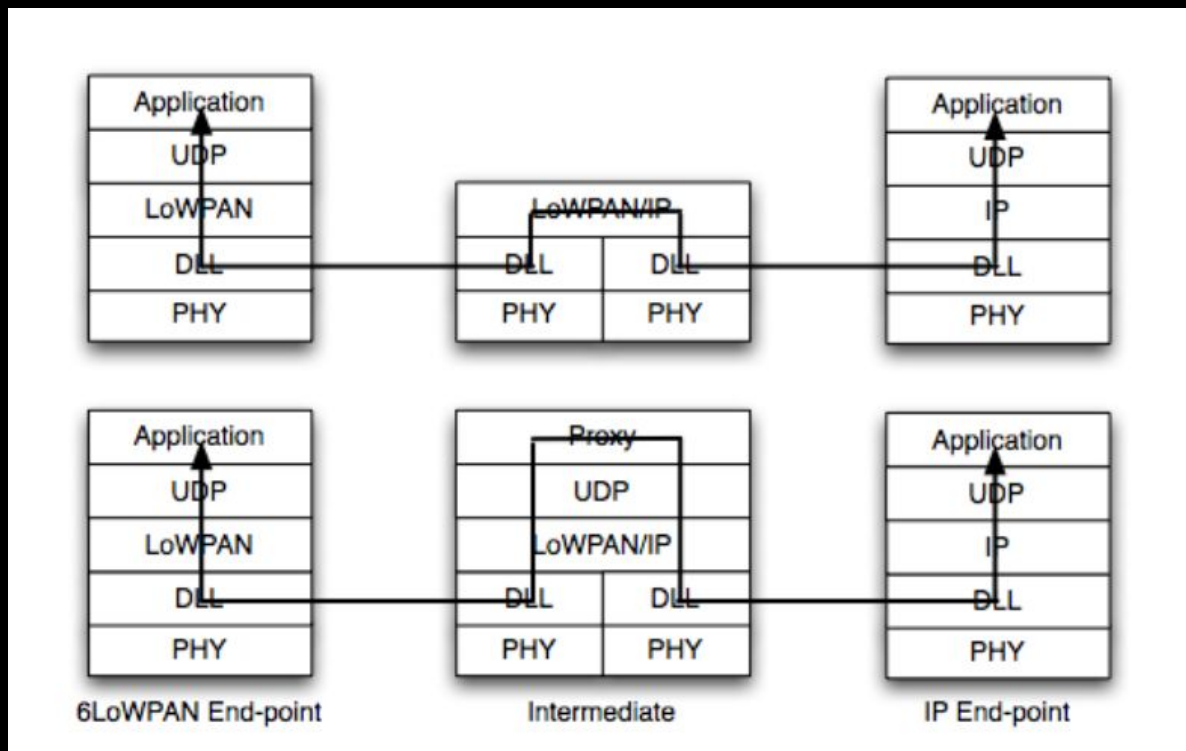
Data Link

Physical

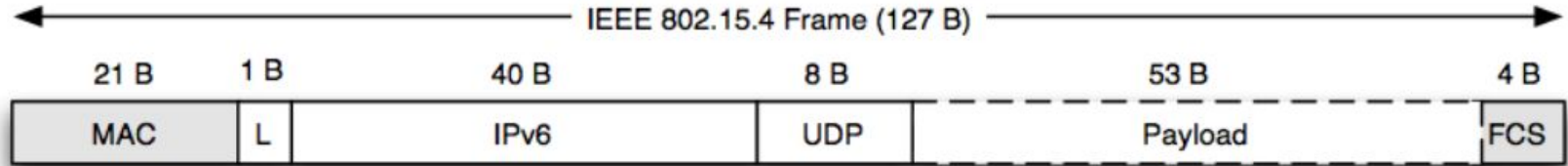
6LoWPAN Protocol Stack

Application	
UDP	ICMP
IPv6 with LoWPAN	
IEEE 802.15.4 MAC	
IEEE 802.15.4 PHY	

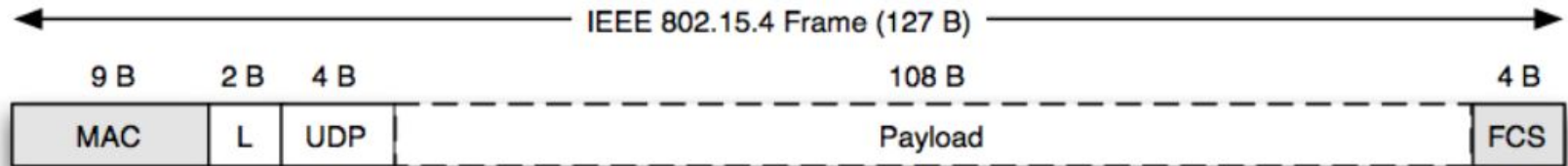
02| Wireless Sensor Networks



02| Wireless Sensor Networks

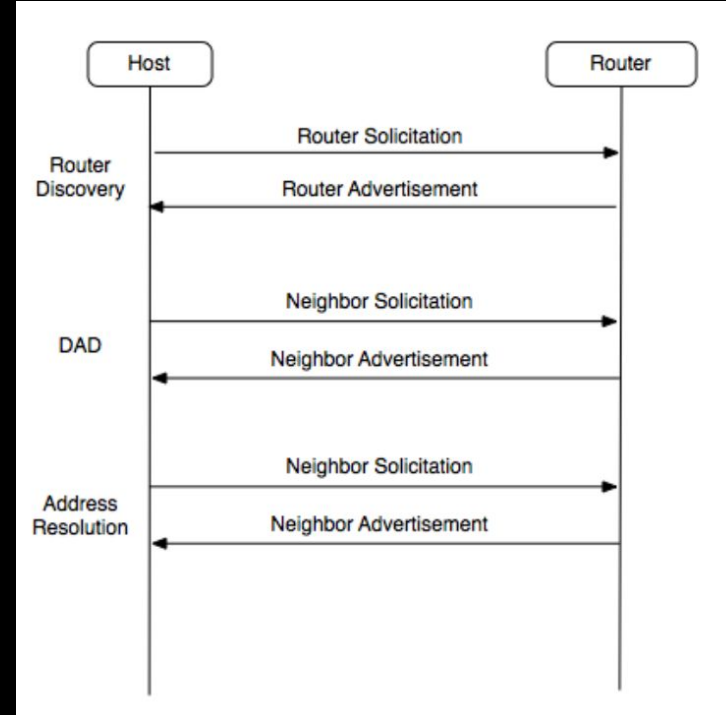
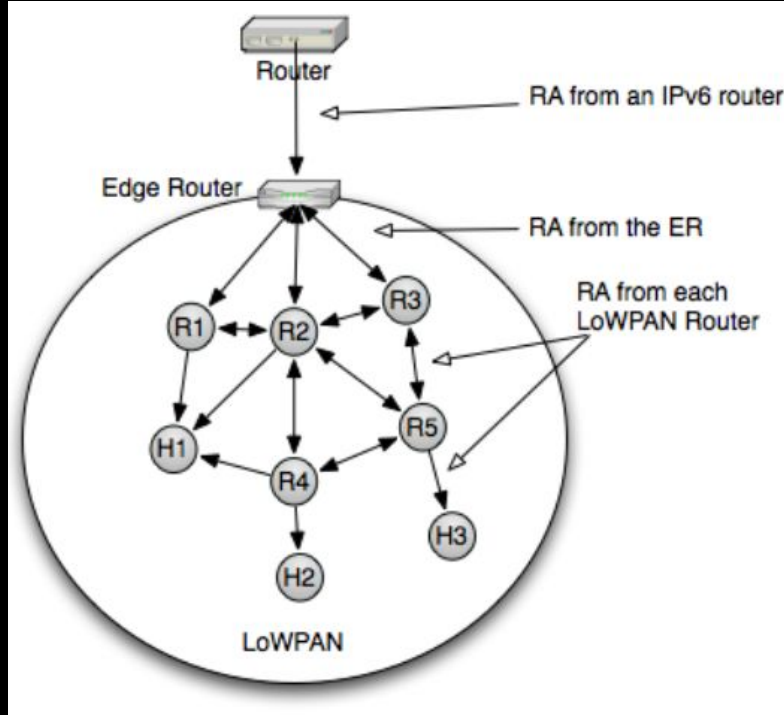


Full UDP/IPv6 (64-bit addressing)

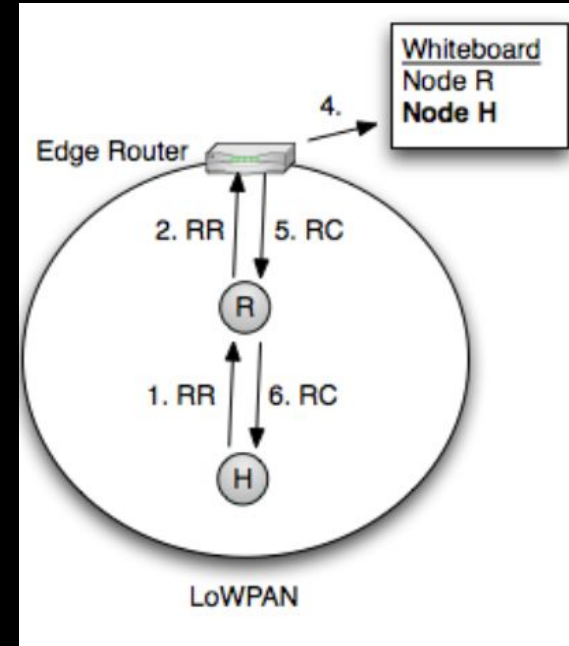
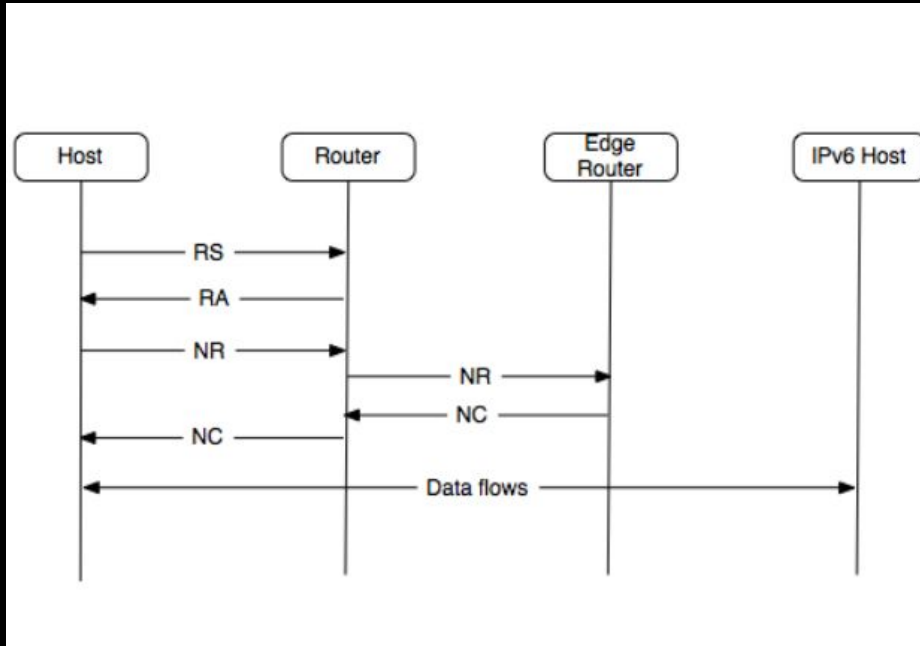


Minimal UDP/6LoWPAN (16-bit addressing)

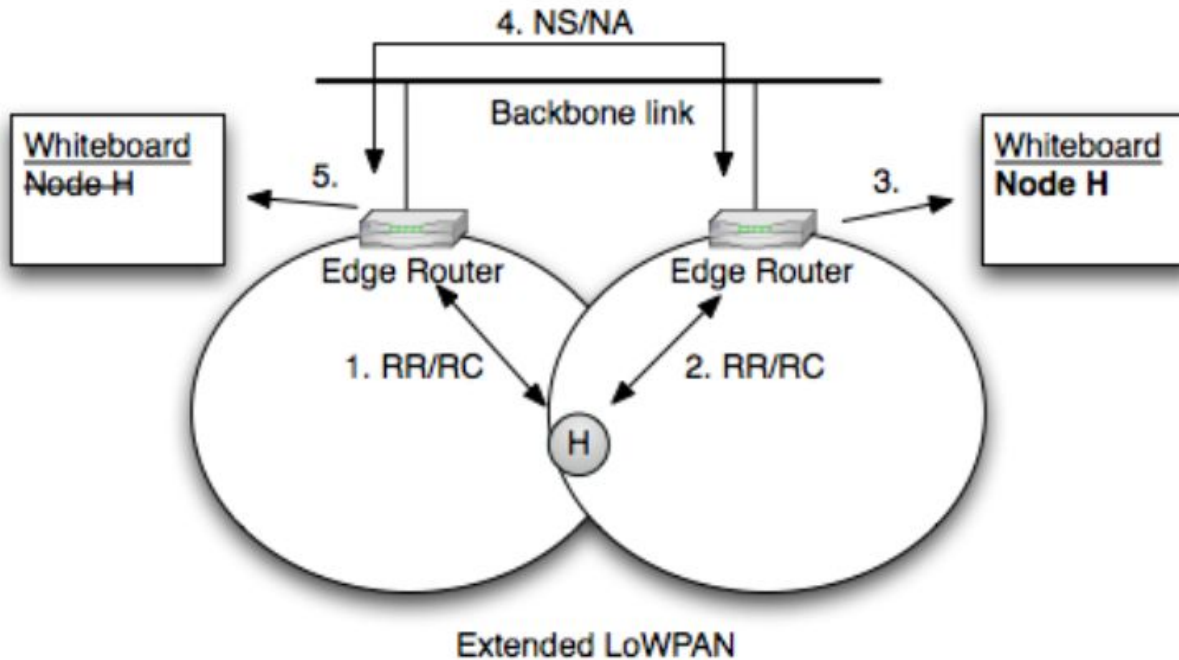
02| IPV6 Neighbor Discovery and network setup



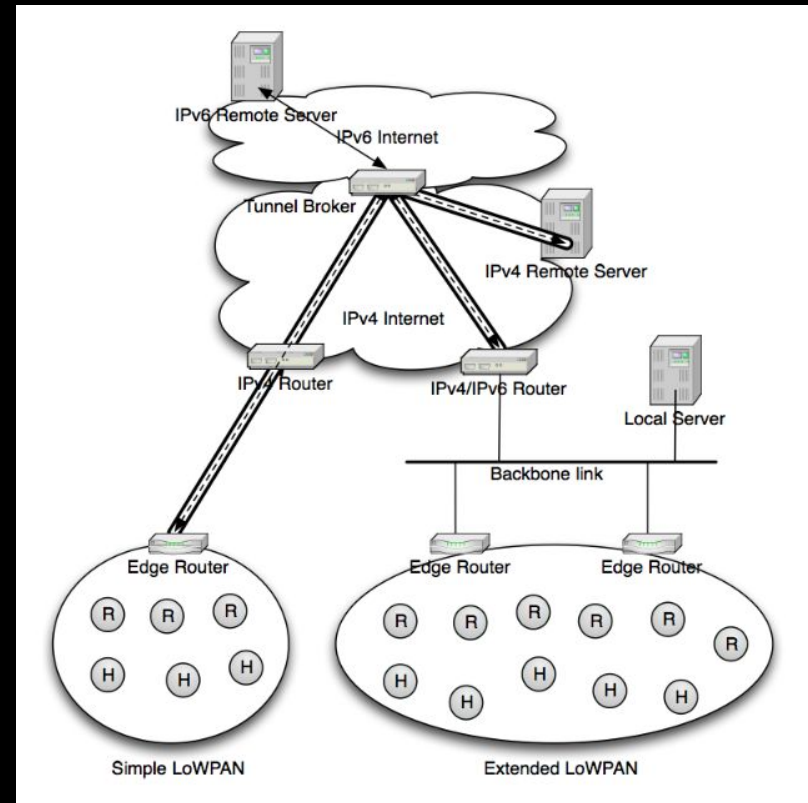
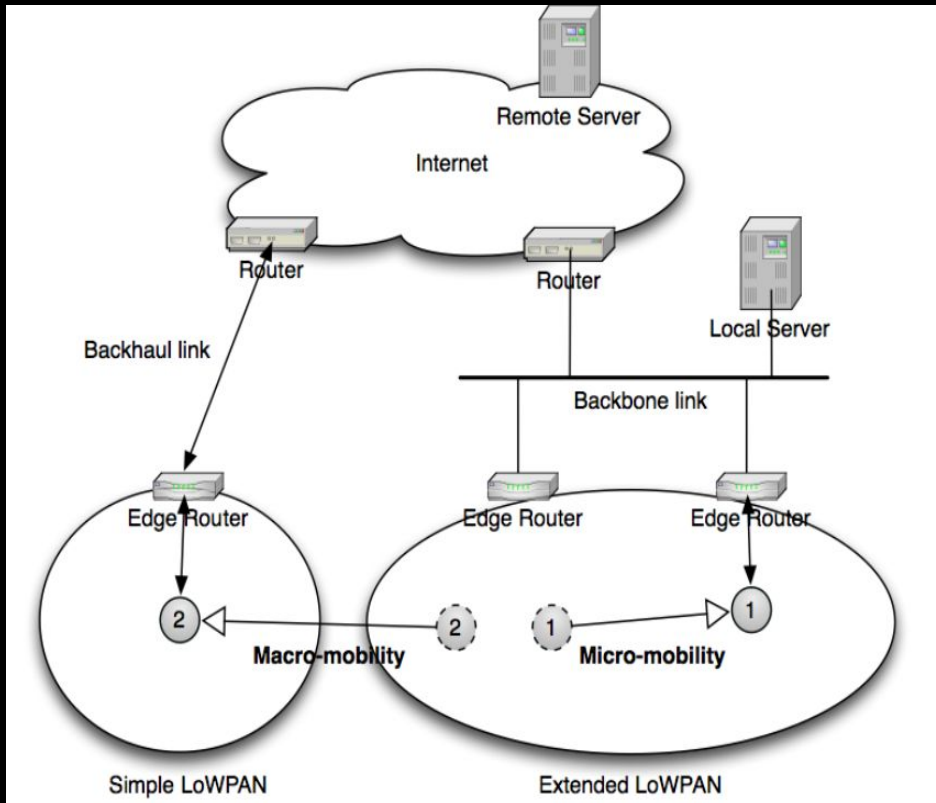
02| IPV6 Neighbor Discovery and network setup



02| IPV6 Neighbor Discovery and network setup



02| Mobility and Network Integration





03|

Contiki Operating System

03| Contiki OS : Overview

Cross-platform

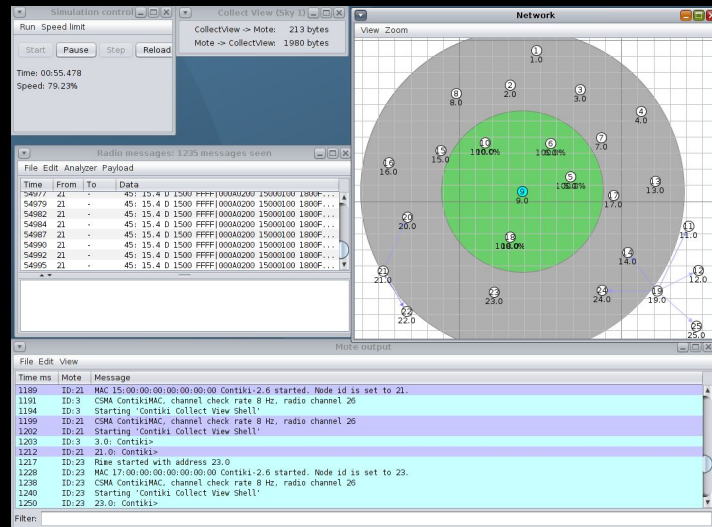
ARM, Atmel AVR, X86, Texas Instruments, Freescale, ...

Contiki Applications

Web server, Web services, Erbiium, Telnet, serial-shell, shell, VNC, Email, IRC, FTP, twitter, calc, Power Trace, Collect view ping, netconf, JSON, etc

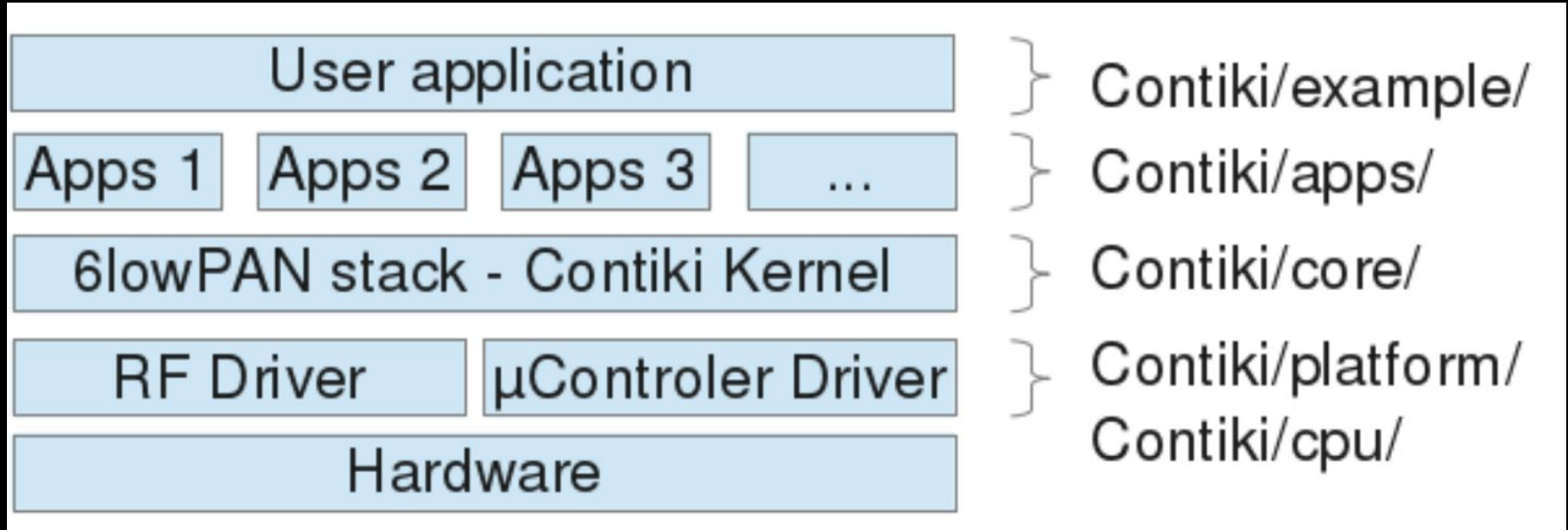
Development environment

Hardware emulator, wireless environment simulator, Linux development toolchain

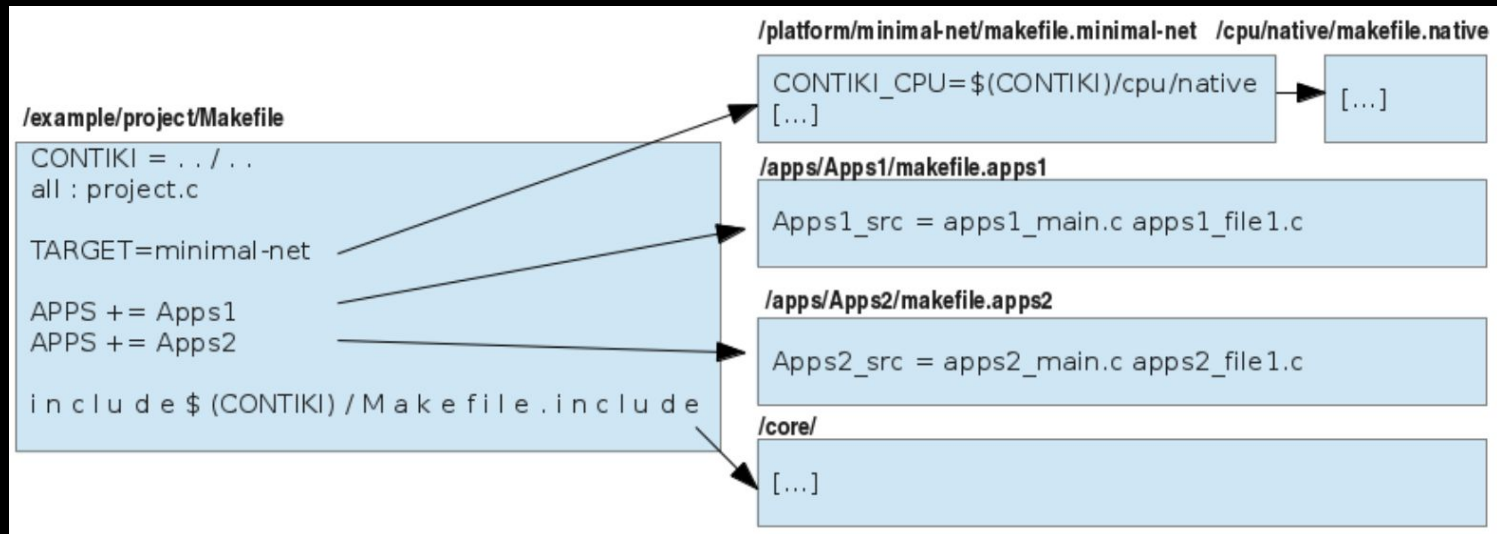


- **Memory-constrained networked embedded systems**
(8Mhz, 16K RAM, 128K ROM, 8K EEPROM)
- **Native 6lowPAN stack with several configuration profiles**
- **Cross-platform implementation**
- **Applications Management System**
- **Event-driven and multi-threading kernel capacities**
- **File Management System - COFFEE**
- **Complete Network Emulator - COOJA**

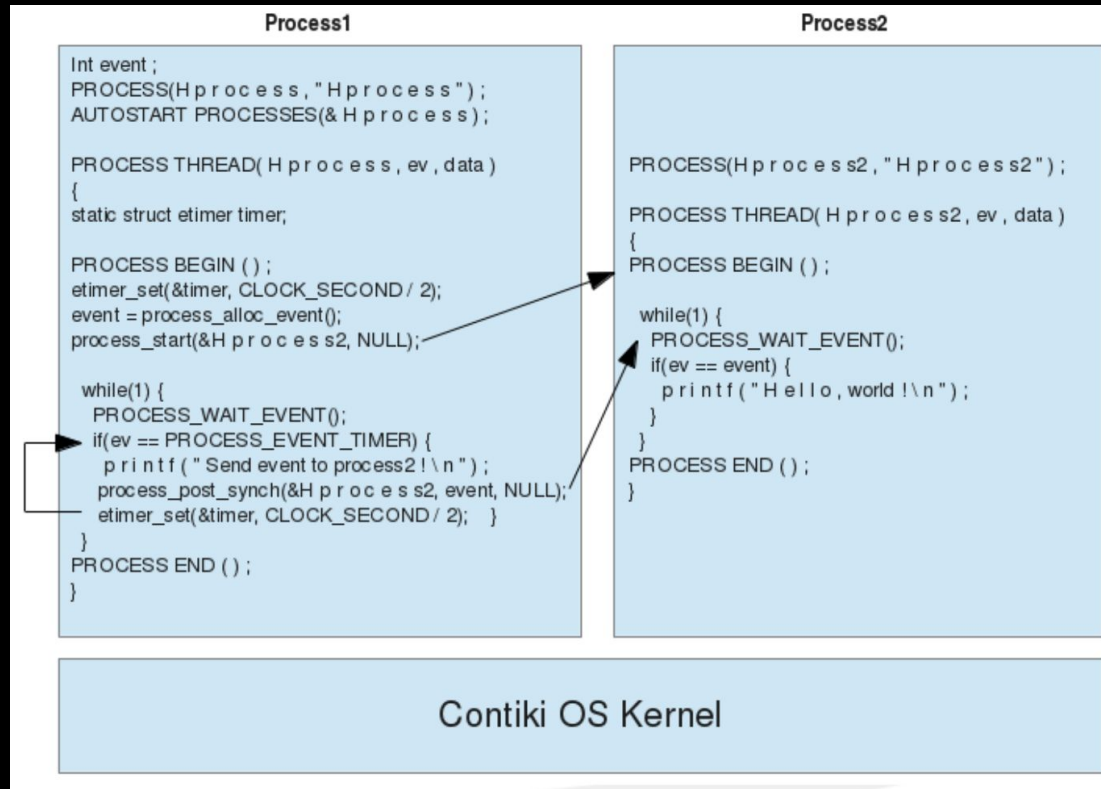
03| Contiki OS : Architecture



03| Contiki OS : Compilation



03| Contiki OS : Proto-Threading



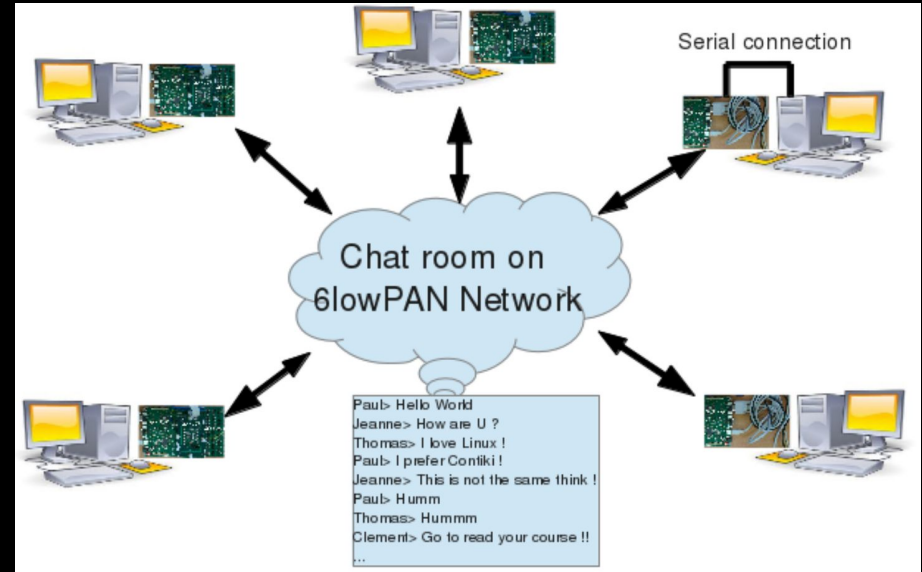


04|

Assignment

04| Assignment

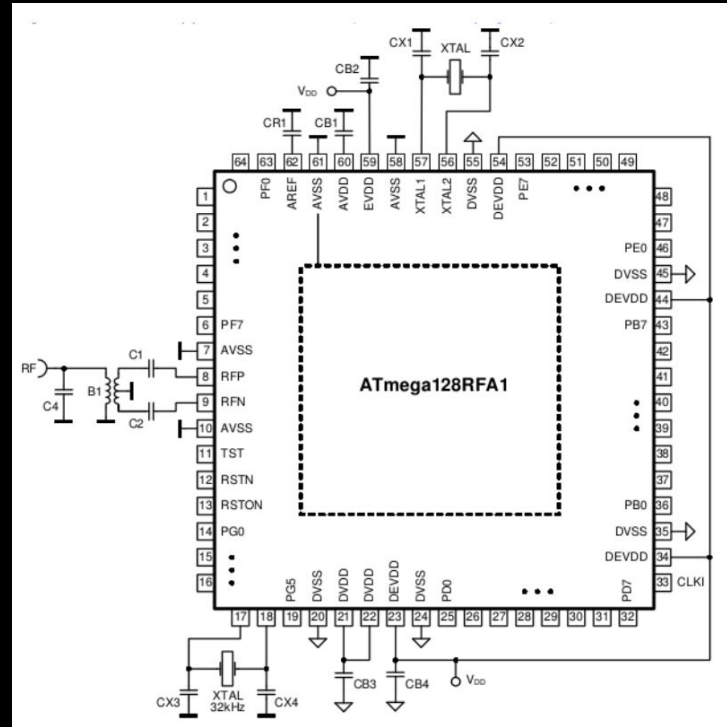
- Experiment COOJA simulations
- First contiki compilation and helloworld
- Develop custom Contiki applications
- Fix bugs and build a patch
- Develop a RS232 shell interface
- Implement the chat project
- Develop an installation procedure



04| Assignment

Atmega 128 RFA1

- I2C
- UART RS 232
- SPI
- ADC
- RF 802.15.4
- AES 128 Bits
- GPIO



04| Assignment

