

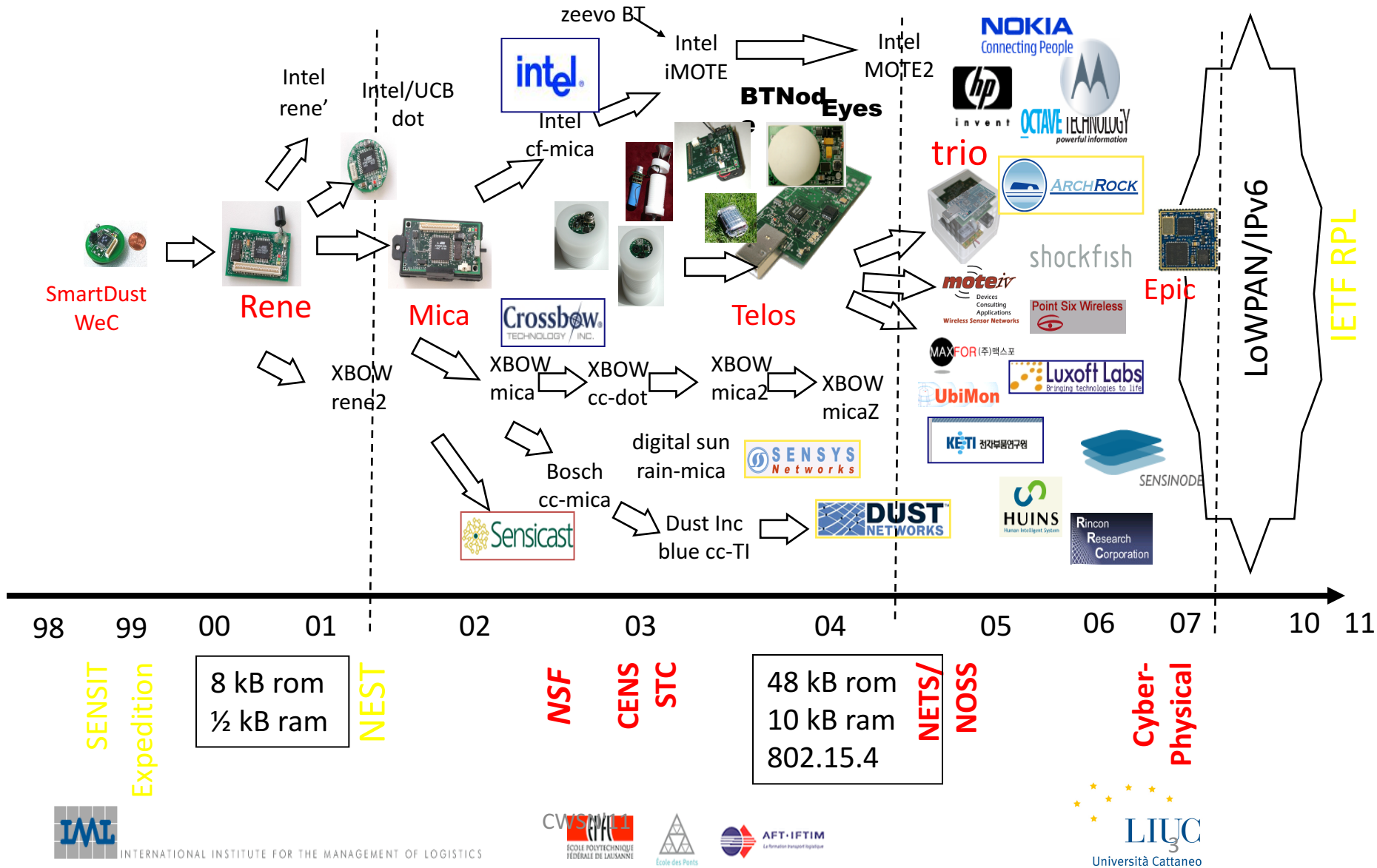
Internet of Things (IoT)

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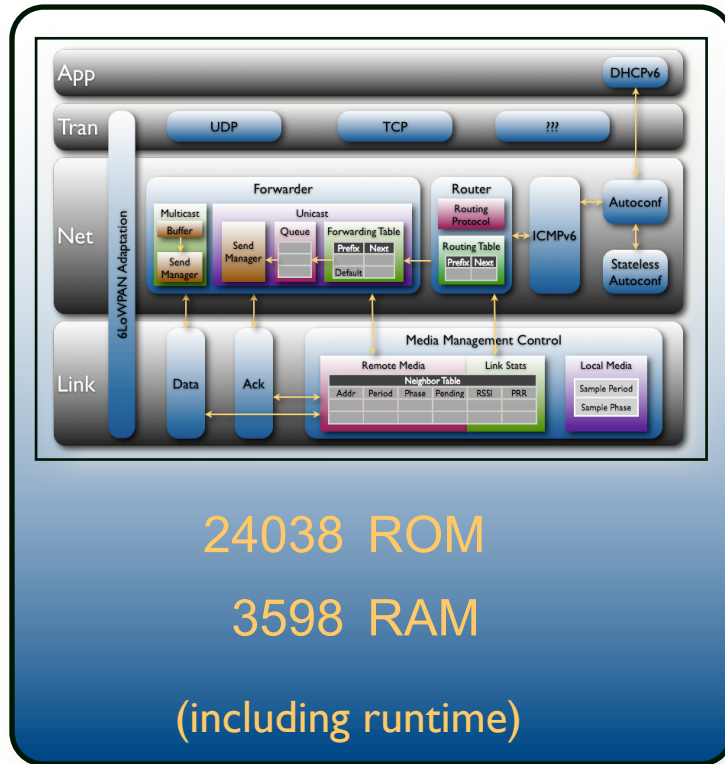
Internet of Things (IoT)

- The story of IoT
- Definition
- Diffusion
- Digital Twins
- Value Added
- Technologies
- Implementation steps
- Today
- Tomorrow
- Conclusion

The Mote/TinyOS revolution...



Internet of Every Thing – Realized 2008

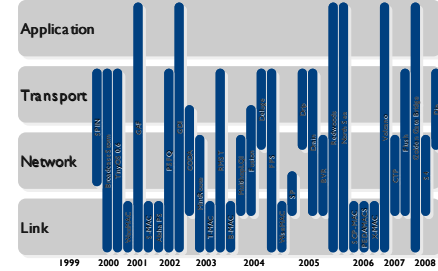


	ROM	RAM
CC2420 Driver	3149	272
802.15.4 Encryption	1194	101
Media Access Control	330	9
Media Management Control	1348	20
6LoWPAN + IPv6	2550	0
Checksums	134	0
SLAAC	216	32
DHCPv6 Client	212	3
DHCPv6 Proxy	104	2
ICMPv6	522	0
Unicast Forwarder	1158	451
Multicast Forwarder	352	4
Message Buffers	0	2048
Router	2050	106
UDP	450	6
TCP	1674	50

* Production implementation on TI msp430/cc2420

- Footprint, power, packet size, & bandwidth
- Open version 27k / 4.6k

Key Research Developments

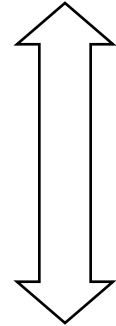


- **Event-Driven Component-Base Operating System**
 - Framework for building System & Network abstractions
 - Low-Power Protocols
 - Hardware and Application Specific
- **Idle listening**
 - All the energy is consumed by listening for a packet to receive
=> Turn radio on only when there is something to hear
- **Reliable routing on Low-Power & Lossy Links**
 - Power, Range, Obstructions => multi-hop
 - Always at edge of SNR => loss is common
=> monitoring, retransmission, and local rerouting
- **Trickle – don't flood** (tx rate $< 1/\text{density}$, and $< \text{info change}$)
 - Connectivity is determined by physical points of interest, not network designer.
 - never naively respond to a broadcast
 - re-broadcast very very politely

Low Power Networking in the Real World



Applications

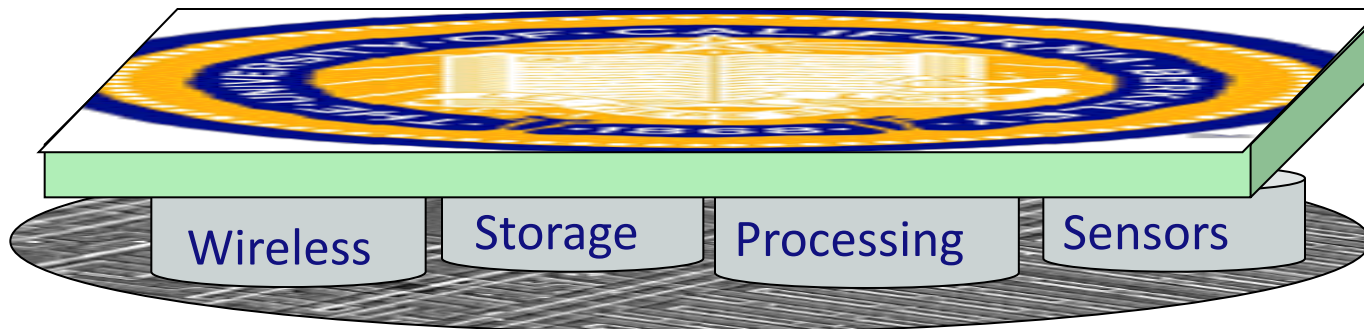


Network

system

architecture

Technology



A Low-Power Standard Link



	802.15.4	802.15.1	802.15.3	802.11	802.3
Class	WPAN	WPAN	WPAN	WLAN	LAN
Lifetime (days)	100-1000+	1-7	Powered	0.1-5	Powered
Net Size	65535	7	243	30	1024
BW (kbps)	20-250	720	11,000+	11,000+	100,000+
Range (m)	1-75+	1-10+	10	1-100	185 (wired)
Goals	Low Power, Large Scale, Low Cost	Cable Replacement	Cable Replacement	Throughput	Throughput

- Low Transmit power, Low Signal-to-noise Ratio (SNR), modest BW, Little Frames

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Definition (source Wikipedia)

The Internet of things (IoT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items

embedded

with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data.

Definition (source Wikipedia)

- In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as
- **"the infrastructure of the information society."**
- The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.

Definition (source Wikipedia)

- When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities.
- Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

Definition (source Wikipedia)

- When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of **cyber-physical systems**, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities.

Examples (source Wikipedia)

- smart grids

<https://www.youtube.com/watch?v=JwRTpWZReJk>

- smart homes

<https://www.youtube.com/watch?v=0QCDOdW5csU>

- intelligent transportation

<https://www.youtube.com/watch?v=oQpU39CyLa0>

- smart cities

<https://www.youtube.com/watch?v=Br5aJa6MkBc>