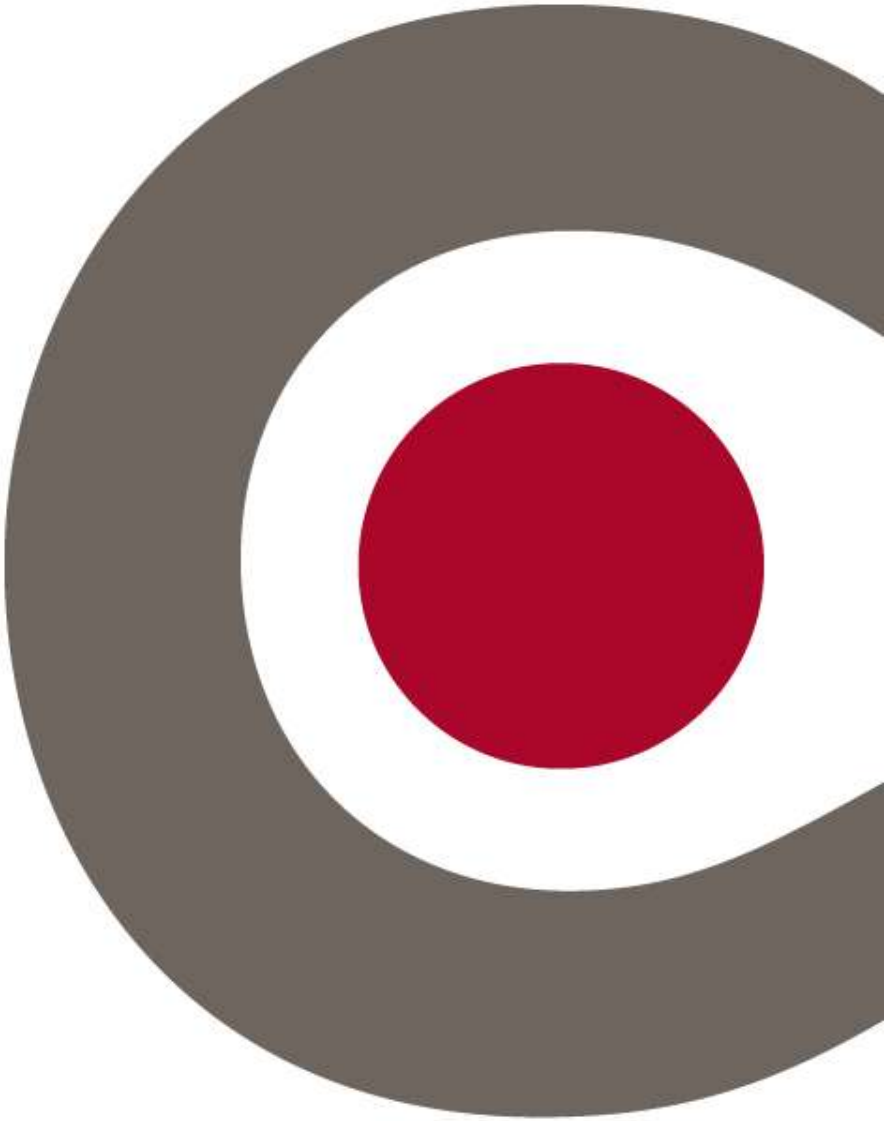

What are Smart Objects and the Internet of Things?

Adam Dunkels, PhD

Swedish Institute of Computer Science

twitter.com/adunk

BusinessWeek

HOME INVESTING COMPANIES TECHNOLOGY INNOVATIC

TECHNOLOGY June 29, 2009, 1:04PM EST

text size: T T

Online Gizmos Could Top 50 Billion in 2020

A senior executive from mobile giant Ericsson says that in 10 years the "Internet of Things" could connect tens of billions of devices wirelessly

By Natasha Lomas

silicon.com

Fifty billion connected devices are coming to cellular networks in the next decade, according to Ericsson—as everyday objects go mobile.

Ericsson's VP of systems architecture, Håkan Djuphammar, predicted the years to come could see connectivity spread to

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San Francisco Business Times

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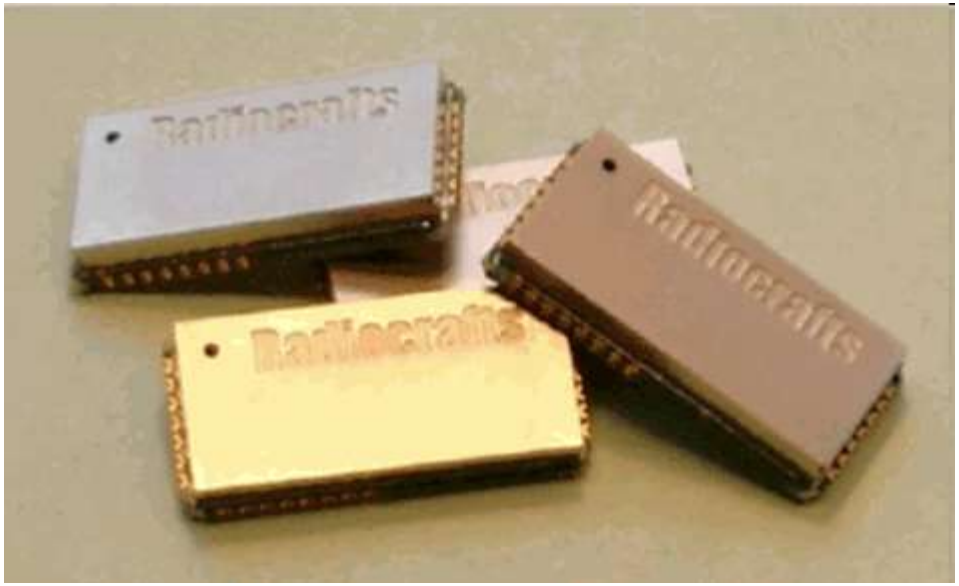
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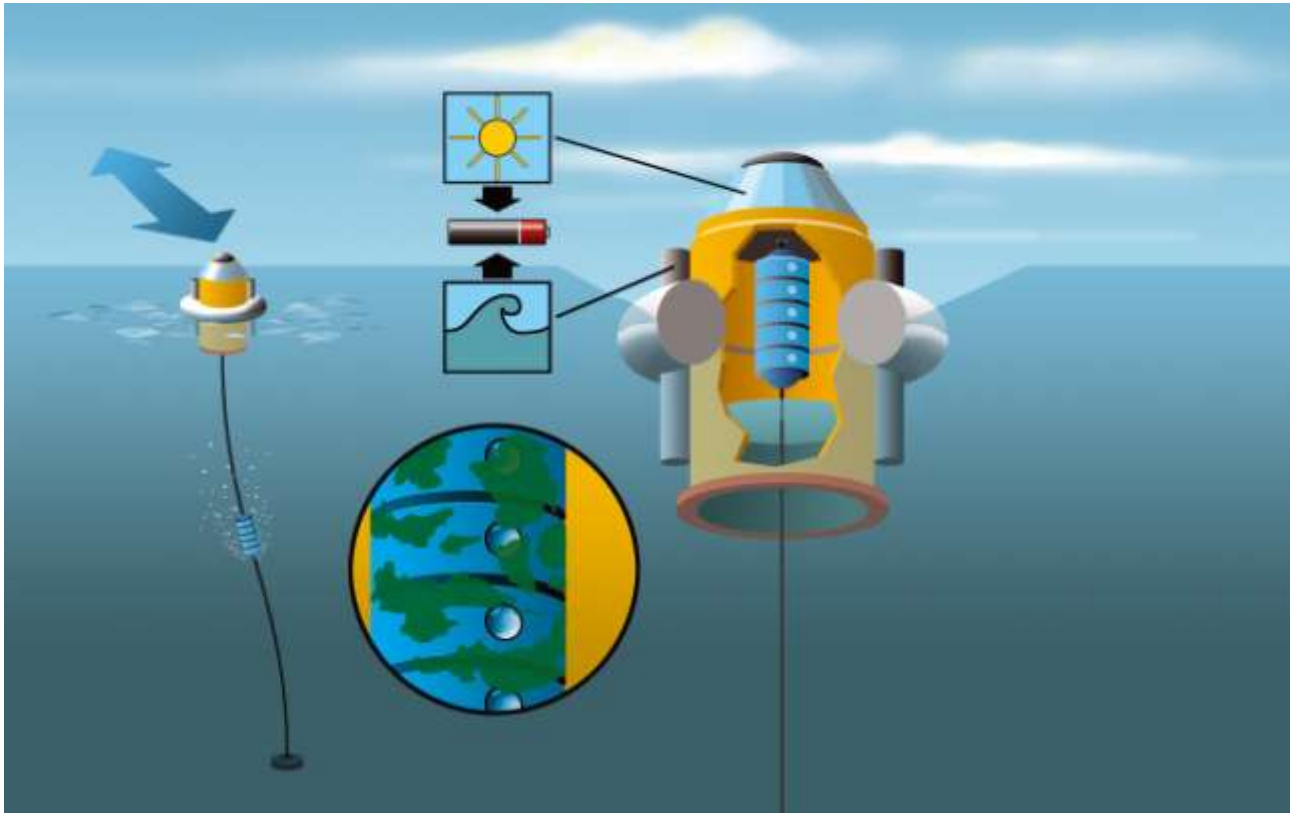
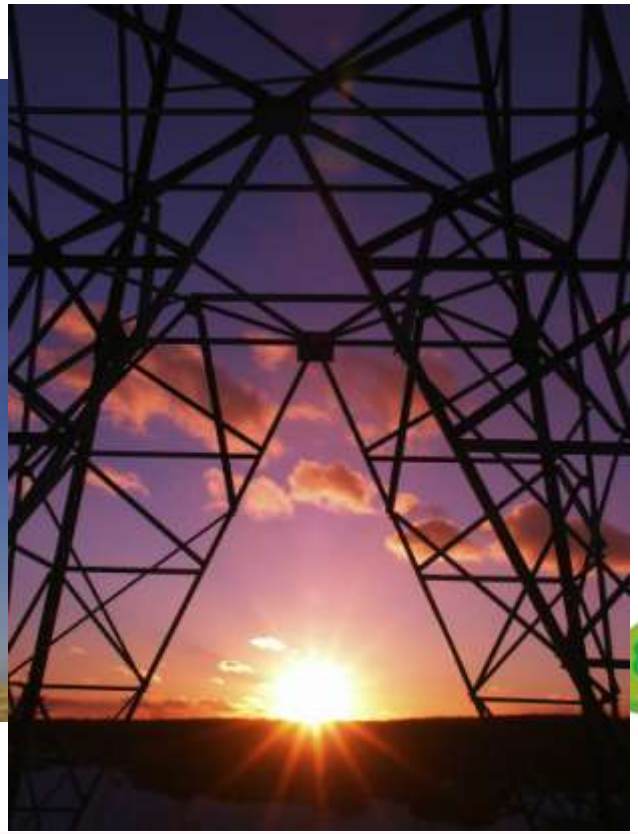
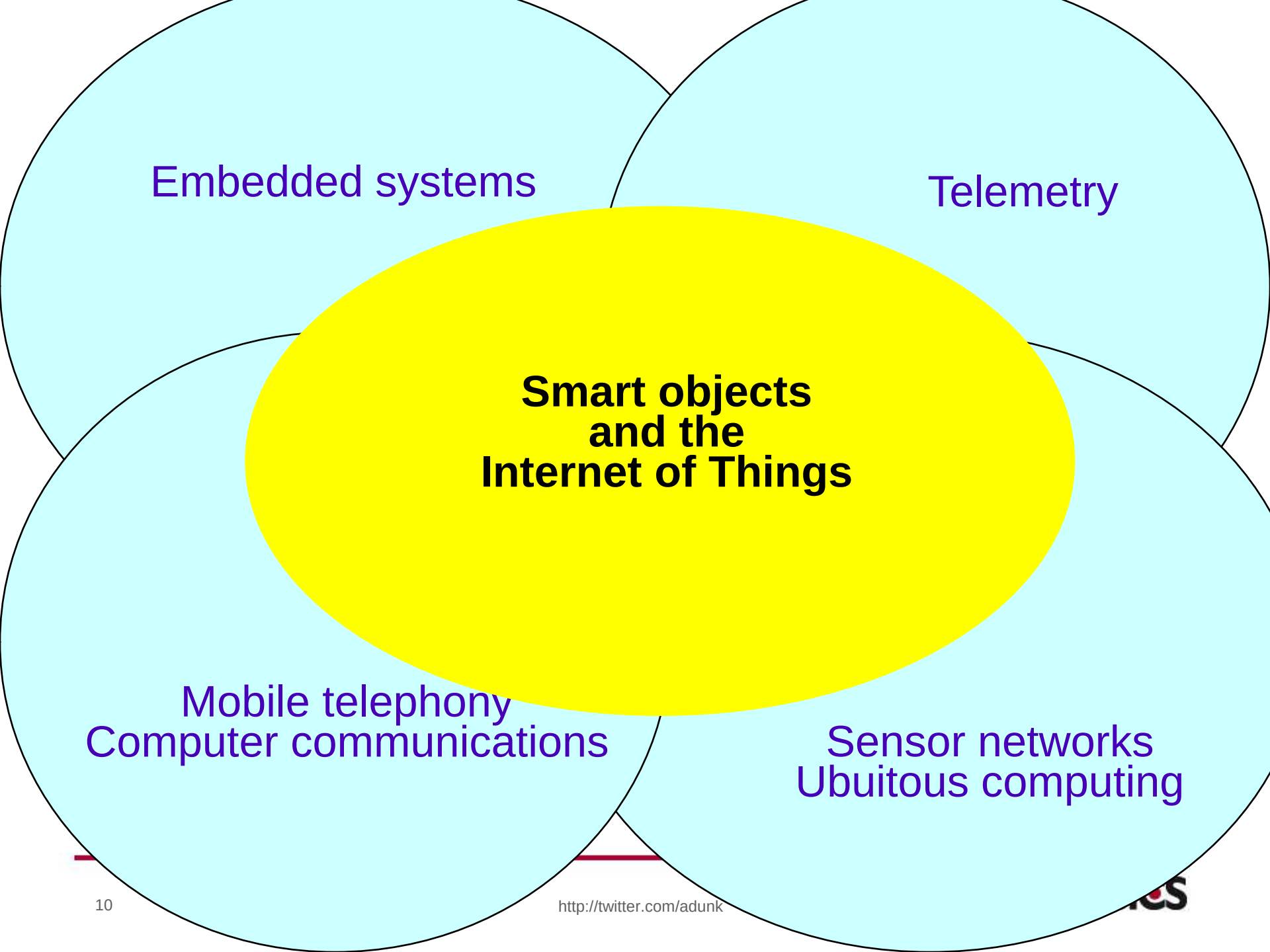


GE/AllSet: Container tracking

ThingMagic: Finding smart objects

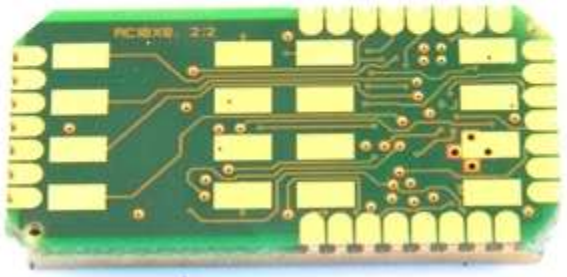
The Smart Grid




Embedded systems
Telemetry
Smart objects
and the
Internet of Things
Mobile telephony
Computer communications
Sensor networks
Ubuitous computing

What is the technology of smart obejcts and the Internet of things?

- Hardware
  - Microcontroller
  - Communication device
    - Low-power radio
    - Power-line communication, …
  - Power source



- Software
  - Lightweight, low-power network operating system

Technical properties and challenges

- Low-power operation
  - < 1 mW
- Small physical size, low cost
  - Tight memory requirements
  - 10 kilobytes of RAM, 100 kilobytes of ROM

Key technical mechanisms

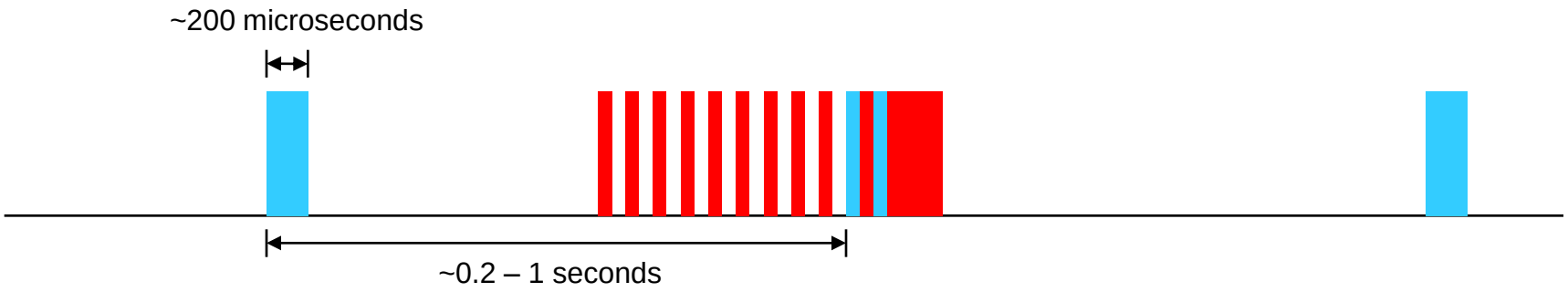
- Low-power radio hardware
- Low-power software mechanisms
- Standards
  - Interoperability, integration with existing systems

Low-power radio hardware

- IEEE 802.15.4
  - Transmit/receive ~60 mW
  - Deep sleep ~0.01 mW
- Low-power WiFi
  - Transmit/receive ~300 mW
  - Deep sleep ~0.02 mW

Low-power software mechanisms

0.1% duty cycle ~= 0.6 mW



Standards

- Link layer
  - IEEE 802.15.4
- ISA100a
- WirelessHART
- ZigBee
- IPv6
  - RPL (routing)
  - 6lowpan (header compression)

FOR IMMEDIATE RELEASE

ZIGBEE ALLIANCE PLANS FURTHER INTEGRATION OF INTERNET PROTOCOL STANDARDS

World's leading low-power wireless networking standard adds new specification featuring seamless integration with global IT networks to portfolio

San Ramon, Calif. – April 27, 2009 – The ZigBee Alliance, a global ecosystem of companies creating standardized wireless solutions for use in energy management, commercial and consumer applications, today announced it will incorporate global IT standards from the Internet Engineering Task Force (IETF) into its specification portfolio of low-power wireless networking standards. This move will expand the growing portfolio of successful ZigBee specifications and should further advance the rapid growth of Smart Grid applications that have widely adopted the proven ZigBee Smart Energy public application profile.

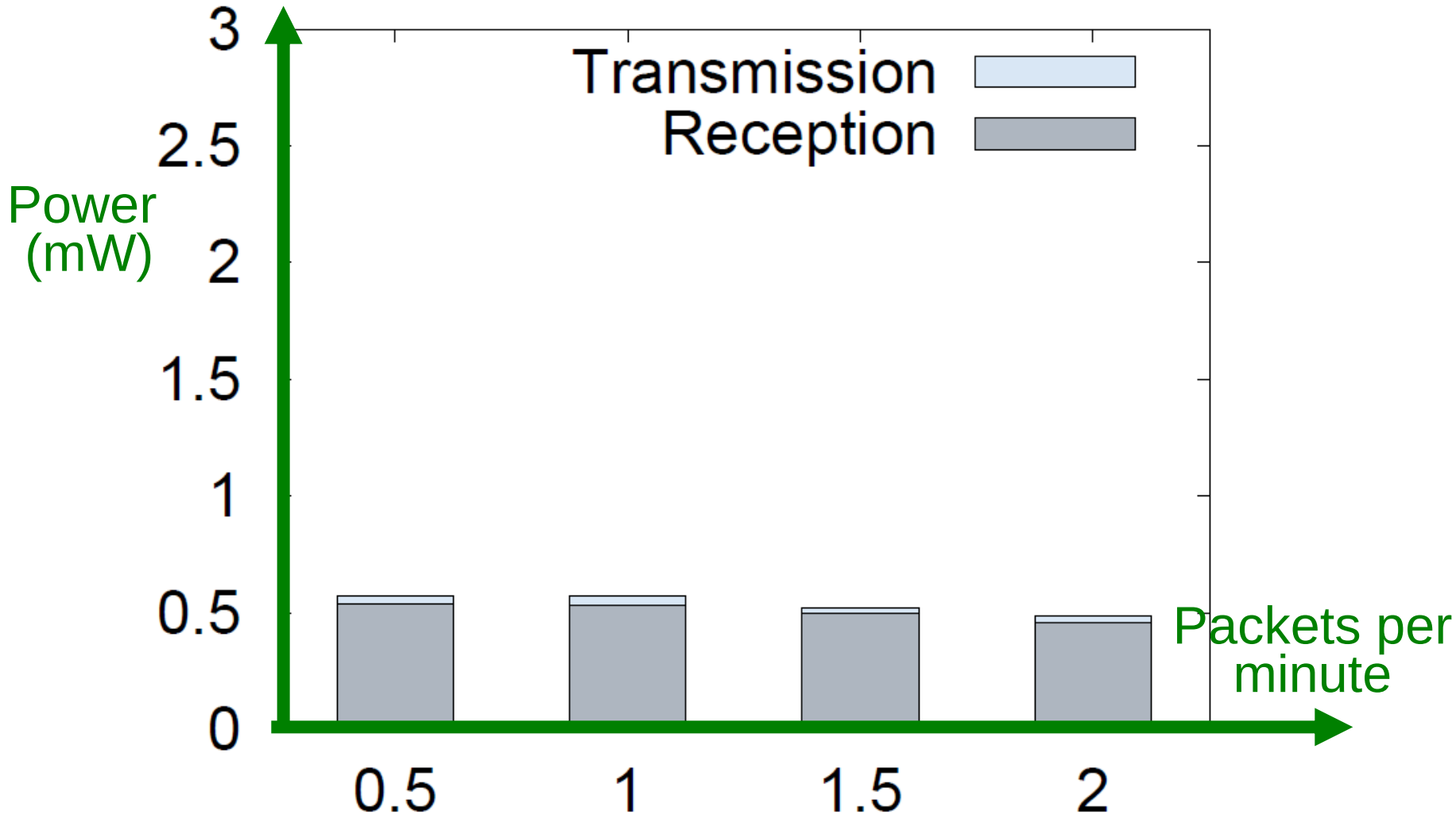
Integration and interoperability

- The Internet Protocol (version 6)
  - Interoperable
  - Evolvable
  - Scalable
  - Standardized
    - RPL, 6lowpan, …
  - Lightweight ?
  - Low power ?

October 2008: Contiki, world's smallest IPv6 stack

- uIPv6
  - 11 kilobytes of code, 2 kilobytes of RAM
  - SICSlowpan IPv6 over 802.15.4 layer
- Fully IPv6 Ready silver logo compliant
  - July 2009: Arch Rock Corp.

Contiki: low-power IPv6



IP for Smart Objects Alliance

Commissariat a l'Energie Atomique
CENTRIA
ece PARIS
eliko
Landis+Gyr
MAXFOR(주)맥스포
mocana
ember
elster
EMERSON Climate Technologies
Google
IAR SYSTEMS
NATIONAL INSTRUMENTS
NIVIS
primex WIRELESS
FUJITSU
Proto6
SAP
sensinode
BIT
ip infusion
Johnson Controls
LULEÅ UNIVERSITY OF TECHNOLOGY
Jennic
SICS
SIGMA
SILVERSPRING
National Semiconductor
ROAM
SmartSynch
somfy
Sun
TRIDIUM
TAMPERE UNIVERSITY OF TECHNOLOGY
Texas Instruments
Intevia
zero G
ARCH ROCK
ATMEL
augustasystems
BOSCH Invented for life
CISCO
Convergence Wireless
Duke Energy
DUST NETWORKS
ECHELON

SICS

November 2008:
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30. The Internet Of Things

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In September, a group of high-tech companies that includes Cisco and Sun formed the IP for Smart Objects Alliance. Simply put, the organization intends to create a new kind of network that will allow sensor-enabled physical objects — appliances in your home, products in a factory, cars in a city — to talk to one another, the same way people communicate over the Internet.

ILLUSTRATION FOR TIME BY CHRISTOPH NIEMANN

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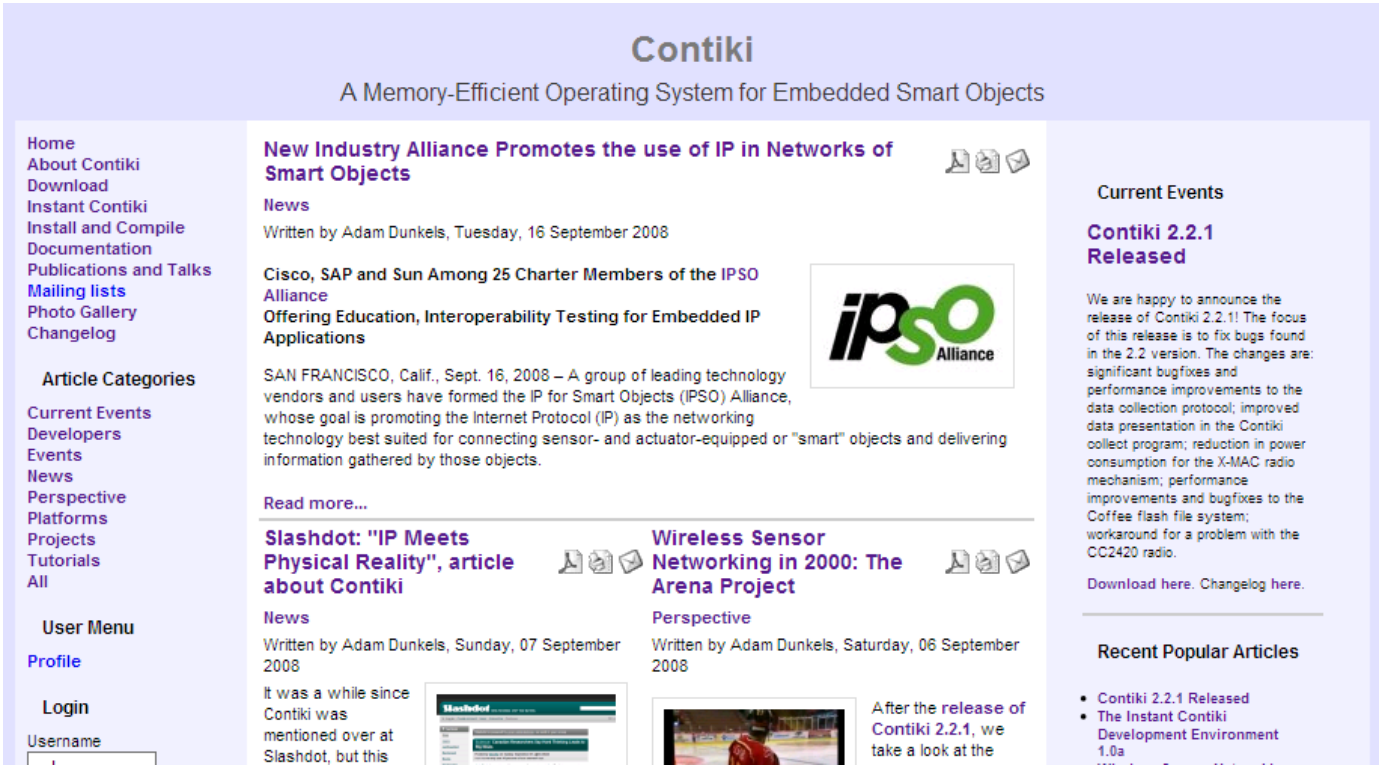
Conclusions

- At the verge of a breakthrough
- The technology:
  - Low-power hardware
  - Low-power software
- IP for Smart Objects
  - Interoperability, scalability, evolvability
  - Lightweight, low-power

Thank You

The Contiki Operating System

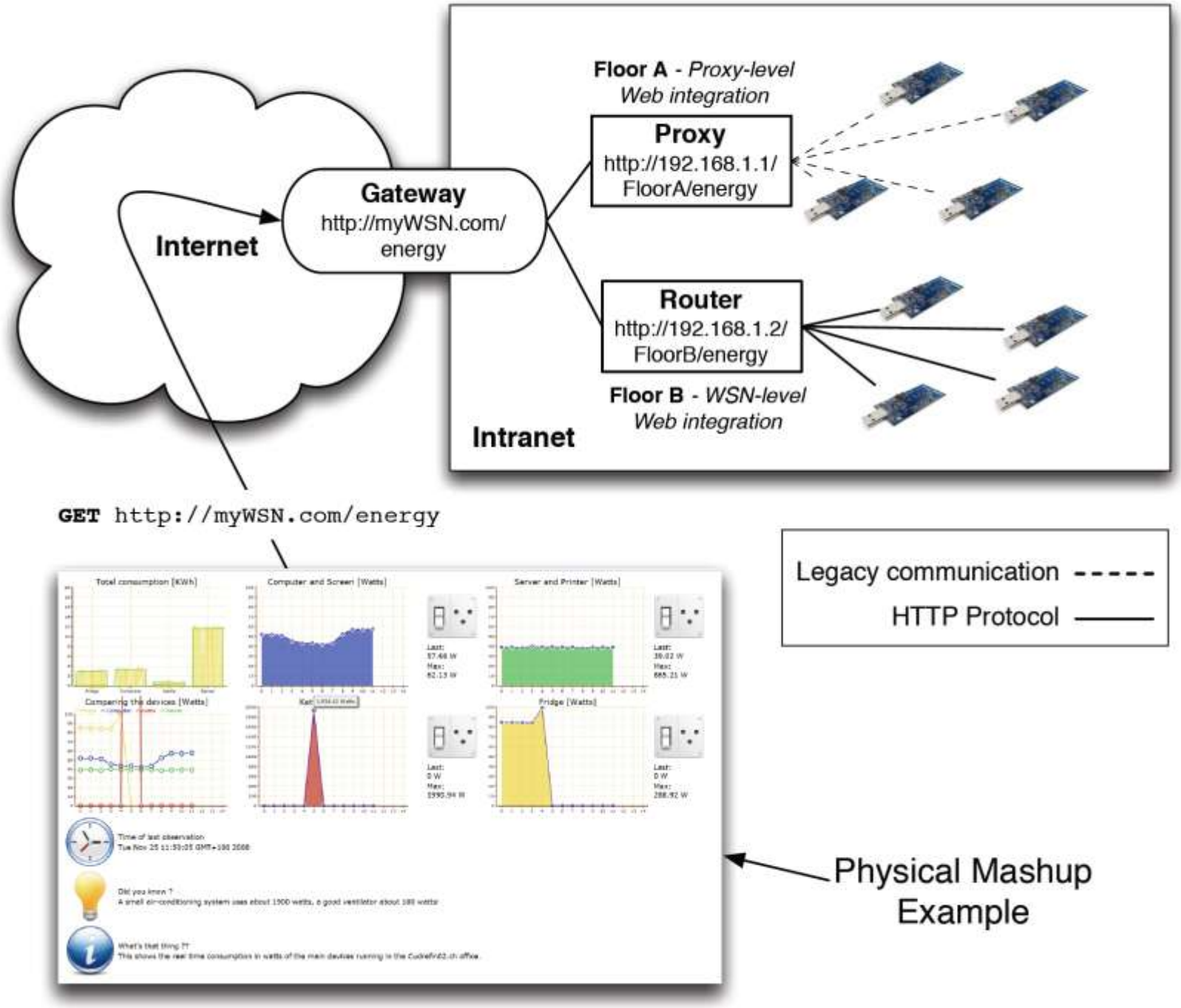
http://www.sics.se/contiki/



Backup

Benefits of integration

- Directly integrate smart objects into a web environment


Floor A - Proxy-level
Web integration
Proxy
http://192.168.1.1/
FloorA/energy
Gateway
http://myWSN.com/
energy
Internet
Router
http://192.168.1.2/
FloorB/energy
Floor B - WSN-level
Web integration
Intranet
GET http://myWSN.com/energy
Total consumption [KWh]
Computer and Screen [Watts]
Server and Printer [Watts]
Comparing the devices [Watts]
Fridge [Watts]
Time of last observation
Did you know ?
What's that thing ??
Legacy communication
HTTP Protocol
Physical Mashup
Example