物联网IP标准初探

北京航空航天大学 机械工程及自动化学院
中国电子学会嵌入式系统专家委员会

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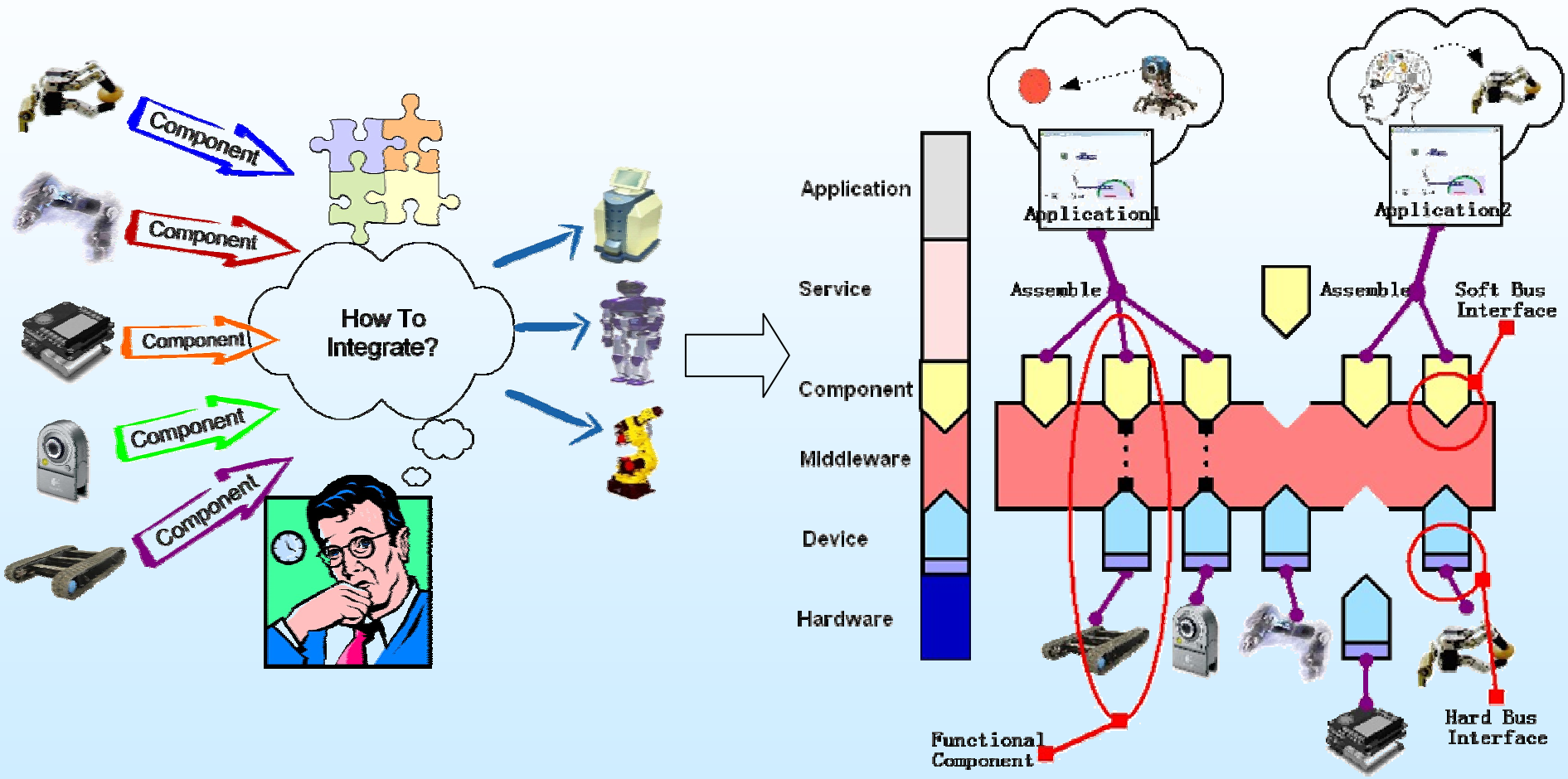
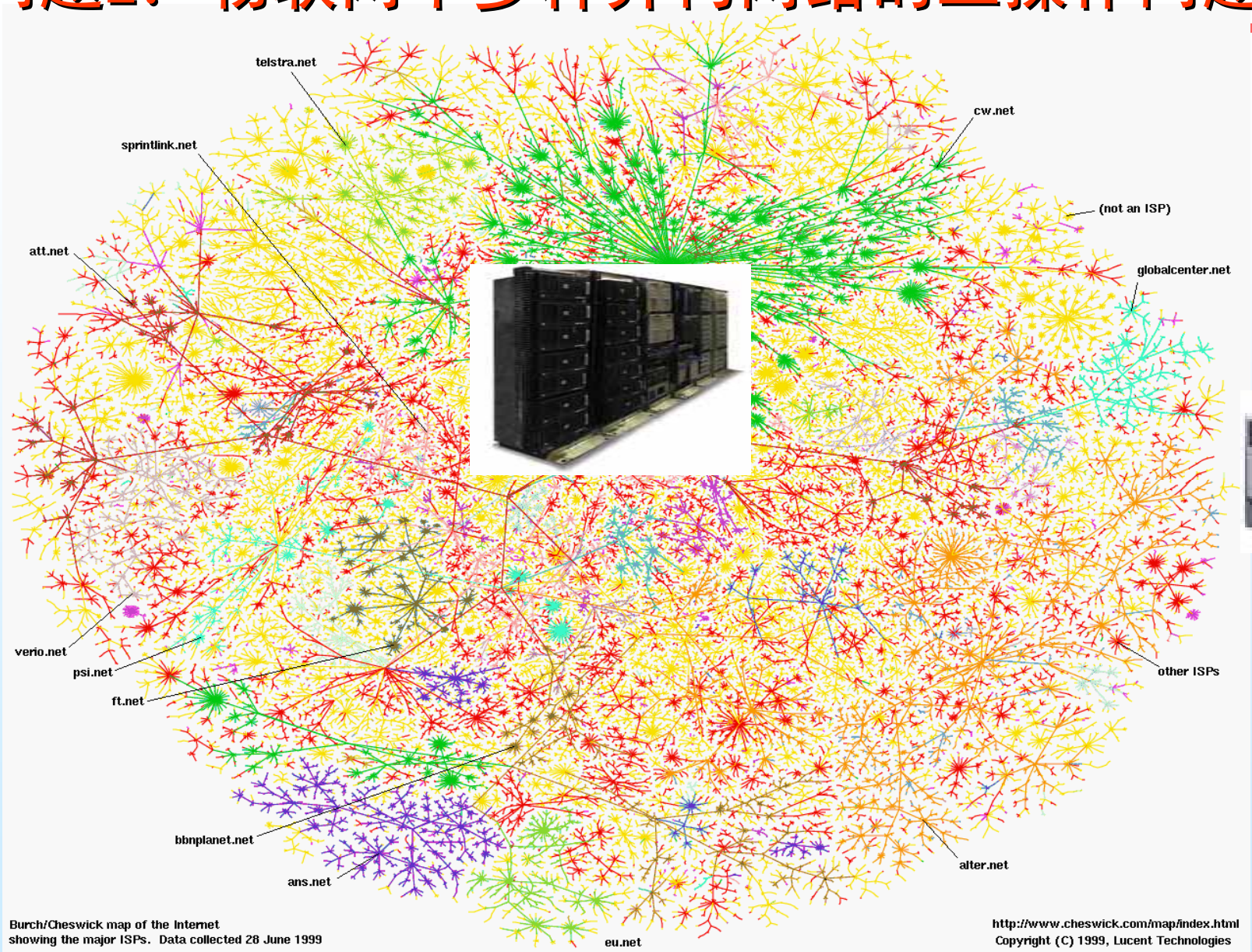
2010年12月

问题1：如何实现不同接口机器人构件的快速集成

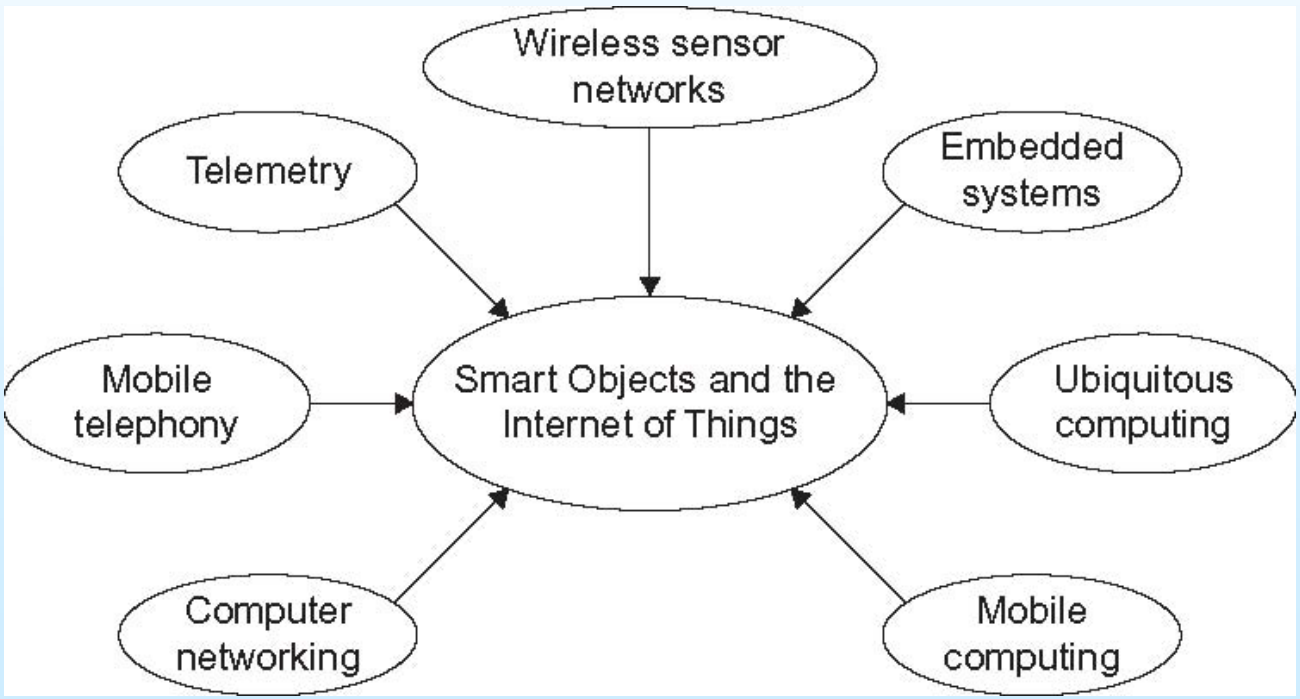


问题2：物联网中多种异构网络的互操作问题



物联网与智能对象（Smart Object）

- 物联网是把大量的智能对象（**Smart Object**）通过私有网络或**Internet**连接起来构成各种应用，包括智能标签**(RFID)**，智能传感器，智能驱动器及任何上述组合构成的其它对象。



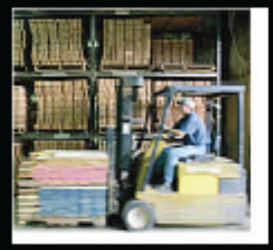
An endless number of applications

Healthcare

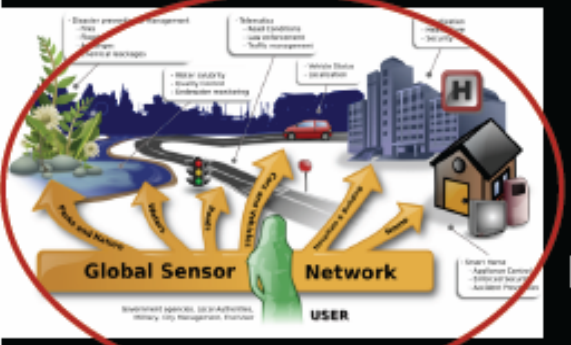
Defense

Predictive maintenance

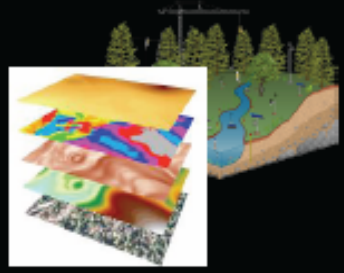
Energy Saving (I2E)



Improve Productivity



Smart Cities



New Knowledge

Intelligent Building

Agricultural

High-Confidence Transport and assets tracking

Industrial Automation

Smart Grid

Smart Home

IEEE 802.15.4 应用联盟

- ZigBee
  - http://www.zigbee.org/
- ZigBee RF4CE
  - http://www.zigbee.org/rFAQ/tabid/413/Default.aspx
- SynkroRF
  - http://www.freescale.com/webapp/sps/site/overview.jsp?nodeId=02205025654CB14C2F
- ISA SP100.11a
  - http://www.isa.org/source/2008_02_ISASeminar_ISA100.11aStatus_Sexton_Kinney.pdf
- WirelessHART
  - http://www.hartcomm2.org/hart_protocol/wireless_hart/wireless_hart_main.html
- ISTEON
  - http://www.insteon.net/developers-about.html

多种协议并存带来的问题与挑战

- 存在大量的不开放或半开放的无线网络协议：Zigbee，Z-Wave，Xmesh，SmartMesh/TSMP等。 … 在不同的协议层(physical，MAC，L3)大多数芯片供应商只与自己的标准兼容；缺乏互操作性。

- 很多缺乏互操作性的解决方案存在很多问题：
  - 不同的体系结构
  - 不同的协议栈

协议转换带来的问题

- 互联网时代使用协议转换处理各种不同环境的应用问题（如SNA, IPX, …）

- 但在物联网时代协议转换方法是不合适的;
  - 管理带来困难和昂贵的费用(固定投资和运营成本);
  - 大量的技术问题需要解决：QoS，自动路由、一致性等;
  - 物联网的应用规模超出想象;
  - 安全漏洞。

我们需要什么样的标准与协议？

体系结构和协议必须具有下面特点：

- 基于开放标准：可以满足互操作性、降低成本和技术创新，所有的不开放的标准与协议都不能满足。
- 灵活的应用方式：
  - 支持各种物理媒介；
  - 支持多种硬件平台。
- 高安全性
- 即插即用
- 可裁剪

IPv6：一种可行的标准

- 开放的标准: The Internet Engineering Task Force
- 应用灵活性:
  - 支持各种接入方式： FR, ATM, Ethernet, Wireless, Optical …
  - 从移动设备到高速路由器
- **Always favor global than local optimum:**

  “IP if good enough for everything: from email to video to realtime protocols”
- 安全性已得到验证
- 十亿以上的IP联网设备

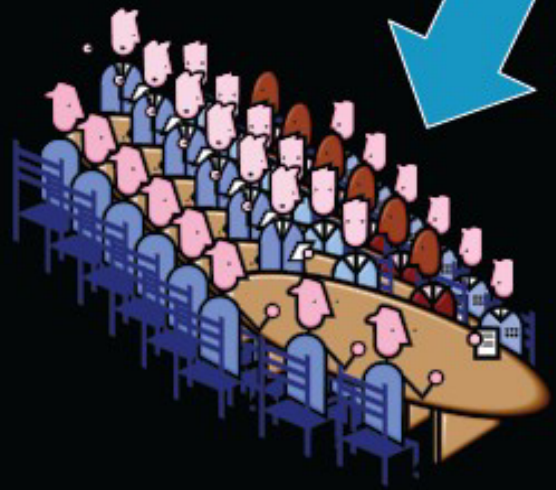
IP-Wireless Sensor Networks (WSN)

- **IP for Smart Objects Alliance (IPSO)**
  - 促进全球智能对象的联网技术;
  - IP可以直接实现传感器与其它简单网络访问连接到Internet, 不需要网络协议转换;
  - 由于使用了轻量级的IP协议，可以有效地降低对处理器速度与内在的要求（如4 Kbytes RAM and 32 Kbytes）;
  - 基于IP的无线传感网络技术，如6LoWPAN（the Internet Engineering Task Force standard for running IPv6 over IEEE 802.15.4 nets）
  - 低能耗自动路由技术（被 Internet Engineering Task Force ）
  - IPv6 可以基于IEEE 802.15.4 网络实现高可靠的自动路由，同时保证较低的功耗。

IPSO IP for Smart Object alliance

September 2008: Alliance launch
27 founding companies

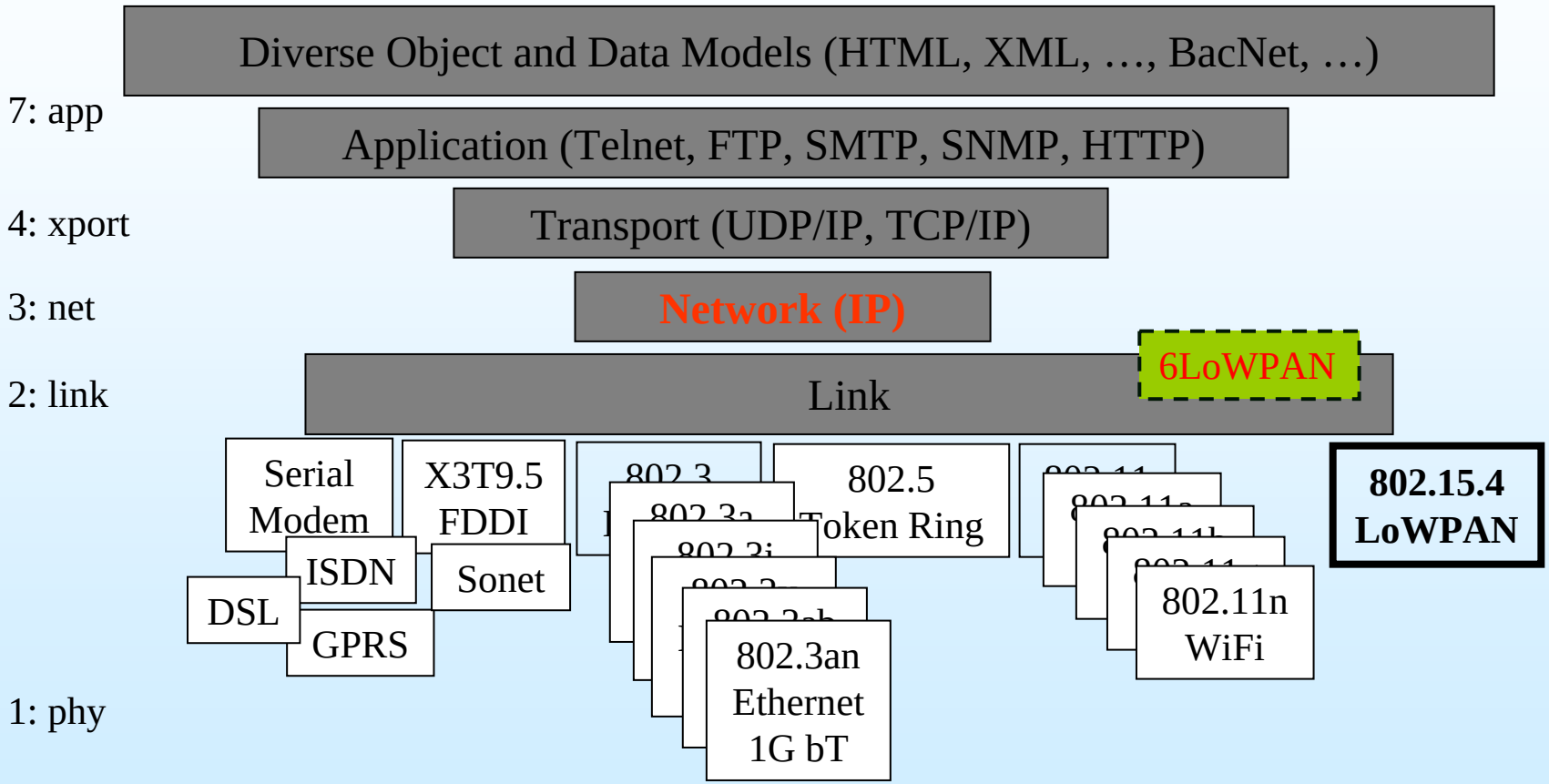
April 2008: 3 persons
Patrick, JP and Roland



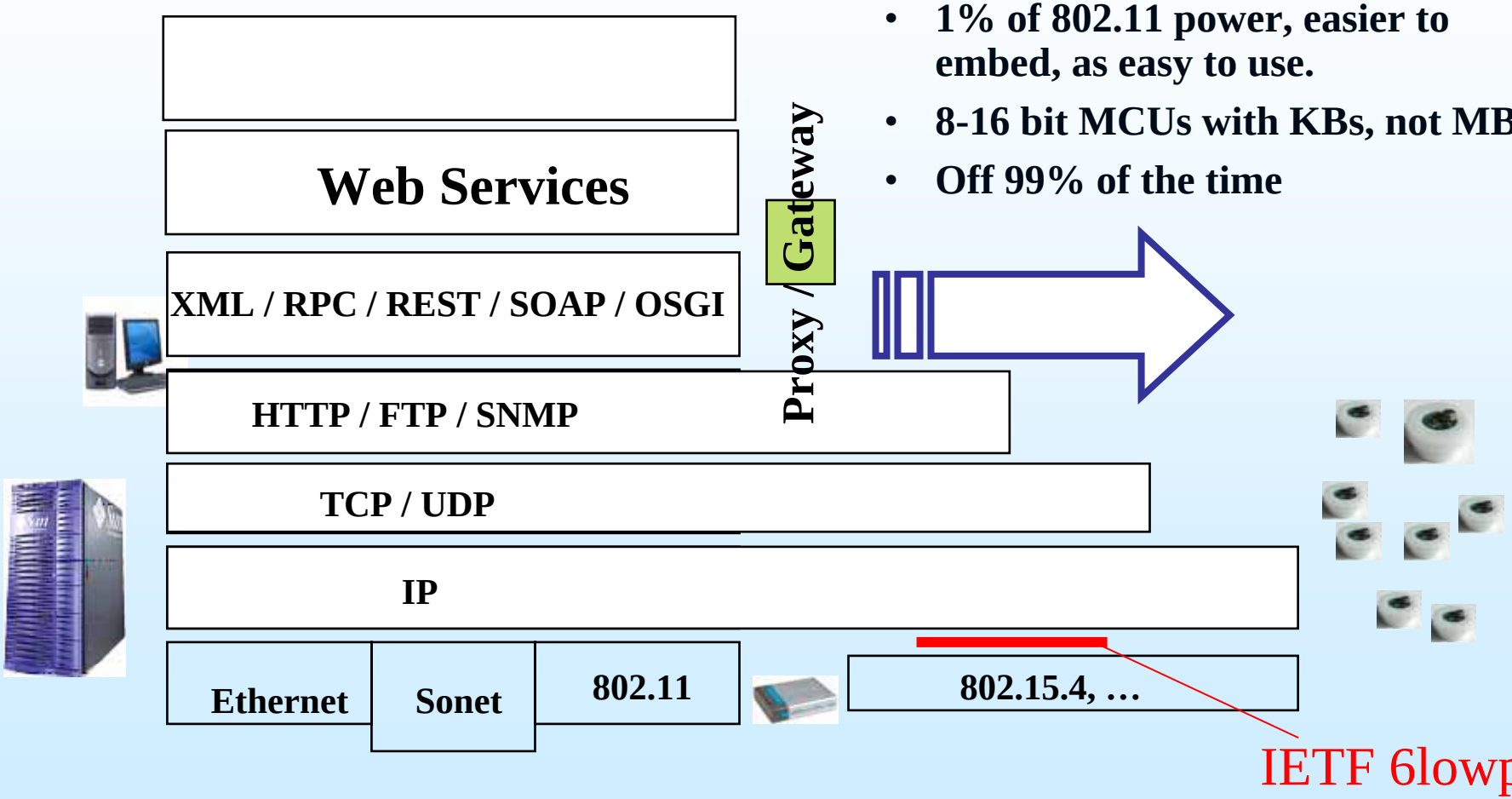
May 2009: 50 members

Arch Rock
Atmel
Bosch
Cisco
Duke Energy
Dust Networks
EDF
ECE
Eka Systems
Ericsson
Freescale
Gainspan
Jennic
Jonhson Control
Intel
INRIA
Kinney Consulting
National Instruments
Nivis
PicosNet
Primex Wireless
Proto6, LLC
SAP
Sensinode
SICS
Sun Microsystems
Tridium
Watteco
Zensys
Centria
Cimetrics
ELIKO
Emerson Climate Technologies
IAR Systems
IP Infusion - An ACCESS Company
Kitworks
Landis & Gyr (Cellnet)
Lulea University of Technology
Mocana
ROAM / Acuity
SilverSpring Networks
SmartSynch
Tampere University of Technology
Texas Instruments
TZ

Internet Concepts: Layering



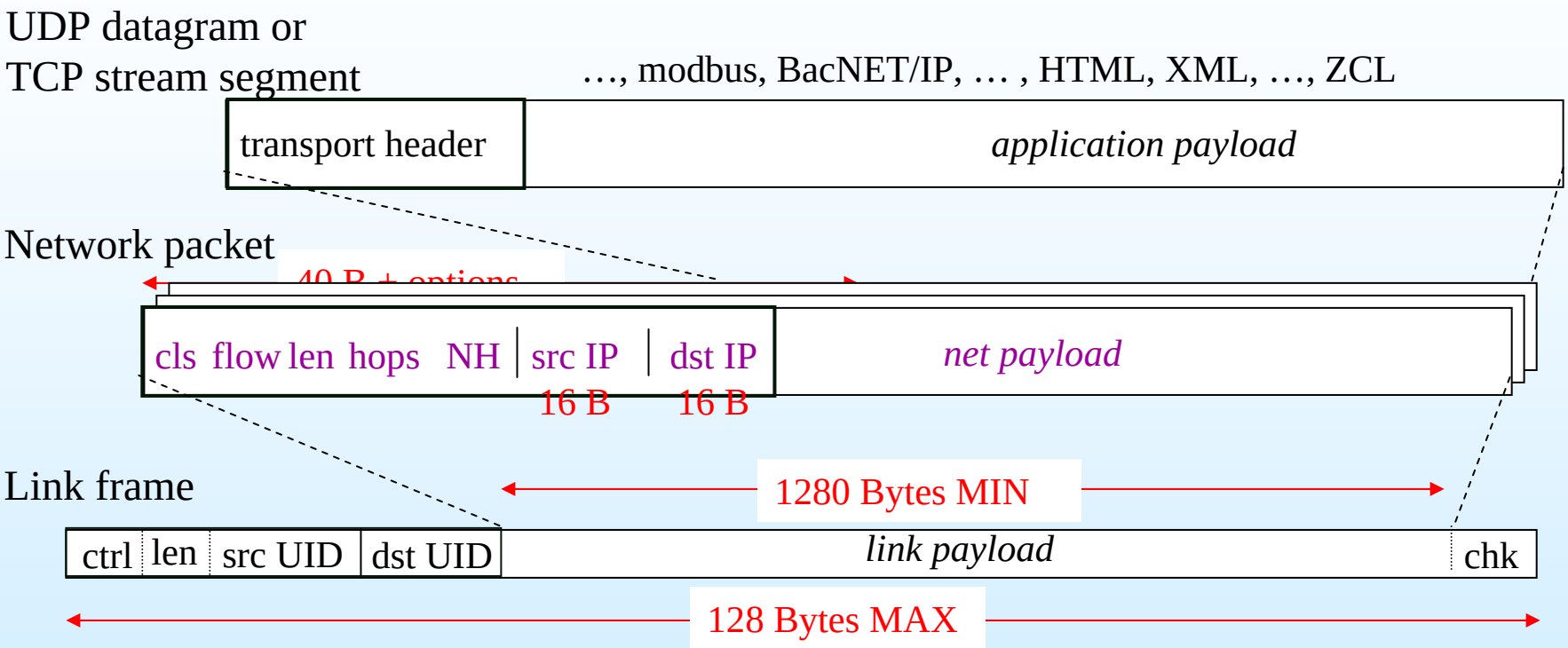
Making sensor nets make sense



基于802.15.4的IP应用关键技术

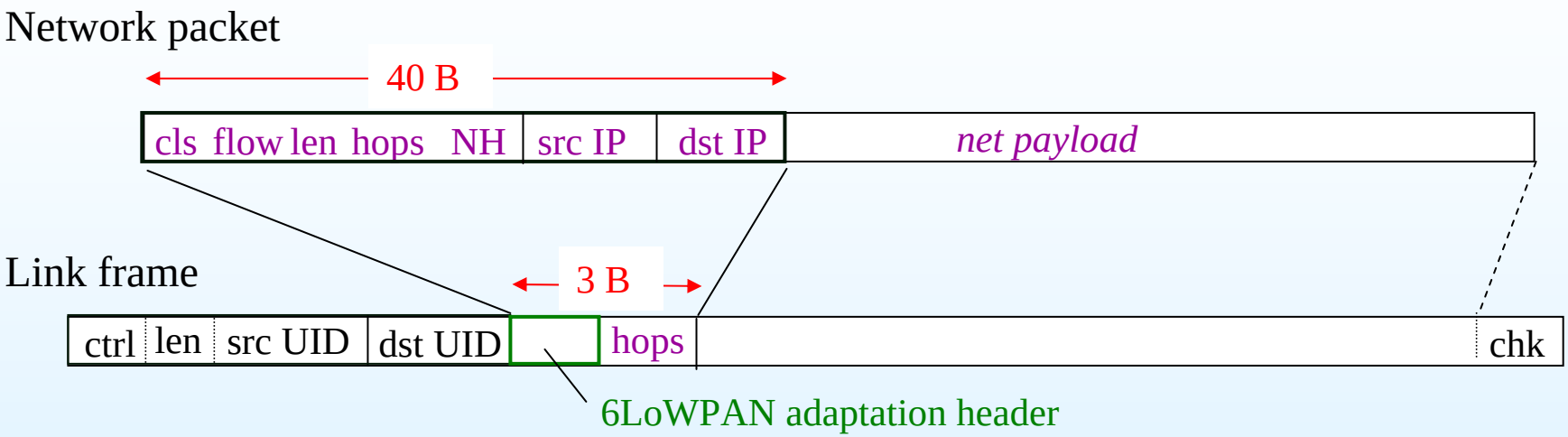
- 帧头
  - Standard IPv6 header is 40 bytes [RFC 2460]
  - Entire 802.15.4 MTU is 127 bytes [IEEE]
  - Often data payload is small
- 分片
  - Interoperability means that applications need not know the constraints of physical links that might carry their packets
  - IP packets may be large, compared to 802.15.4 max frame size
  - IPv6 requires all links support 1280 byte packets [RFC 2460]
- IP路由
  - 802.15.4 subnets may utilize multiple radio hops per IP hop
  - Similar to LAN switching within IP routing domain in Ethernet
- 节能

6LoWPAN Challenges



- Large IP Address & Header => 16 bit short address / 64 bit EUID
- Minimum Transfer Unit => Fragmentation
- Short range & Embedded => Multiple Hops

6LoWPAN - IP Header Optimization



- Eliminate all fields in the IPv6 header that can be derived from the 802.15.4 header in the common case
  - Source address : derived from link address
  - Destination address : derived from link address
  - Length : derived from link frame length
  - Traffic Class & Flow Label : zero
  - Next header : UDP, TCP, or ICMP
- Additional IPv6 options follow as options

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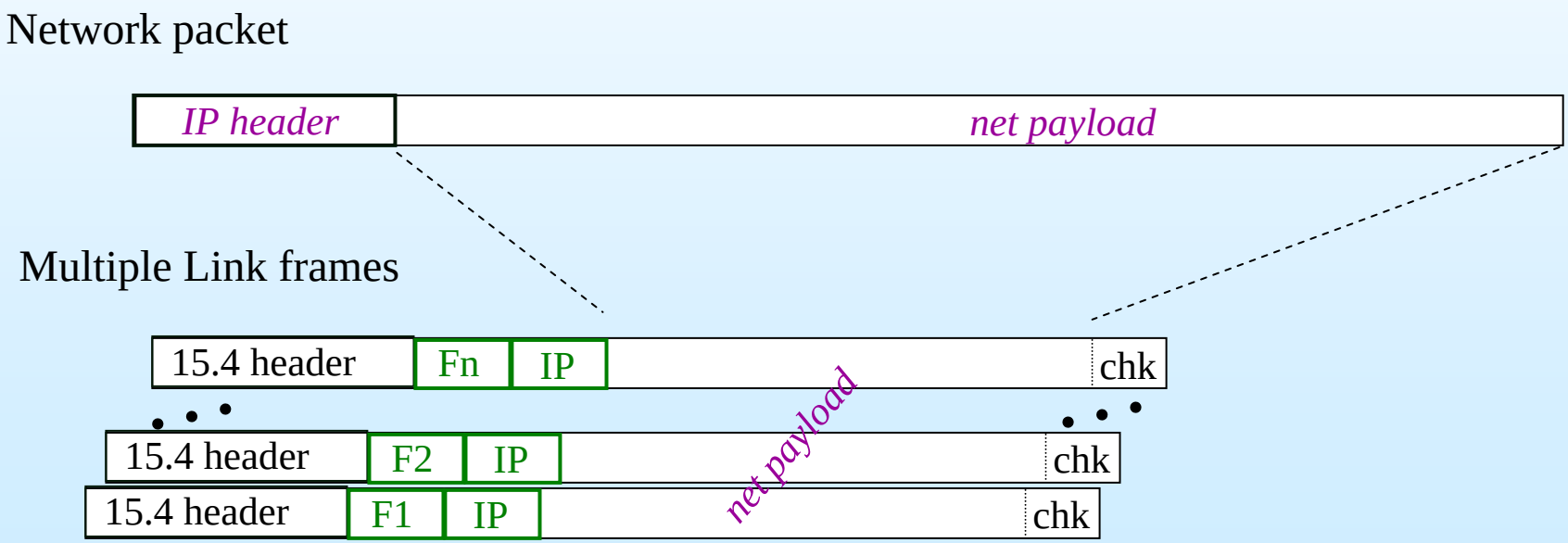
6LoWPAN Fragmentation

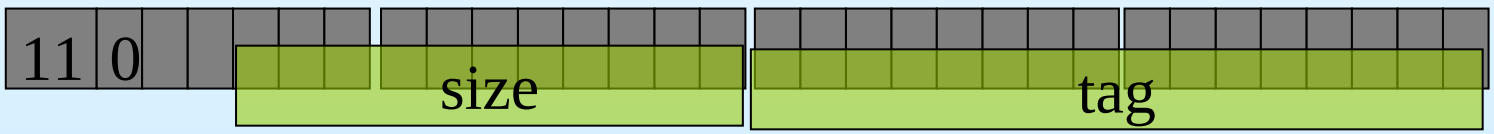
- IP interoperability over many links => users not limited by frame size
- IP datagrams that are too large to fit in a 802.15.4 frame are fragmented into multiple frames
  - Self describing for reassembly



分片

- All fragments of an IP packet carry the same "tag"
  - Assigned sequentially at source of fragmentation
- Each specifies tag, size, and position
- Do not have to arrive in order
- Time limit for entire set of fragments (60s)

First fragment



Rest of the fragments

基于802.15.4的IP应用关键技术

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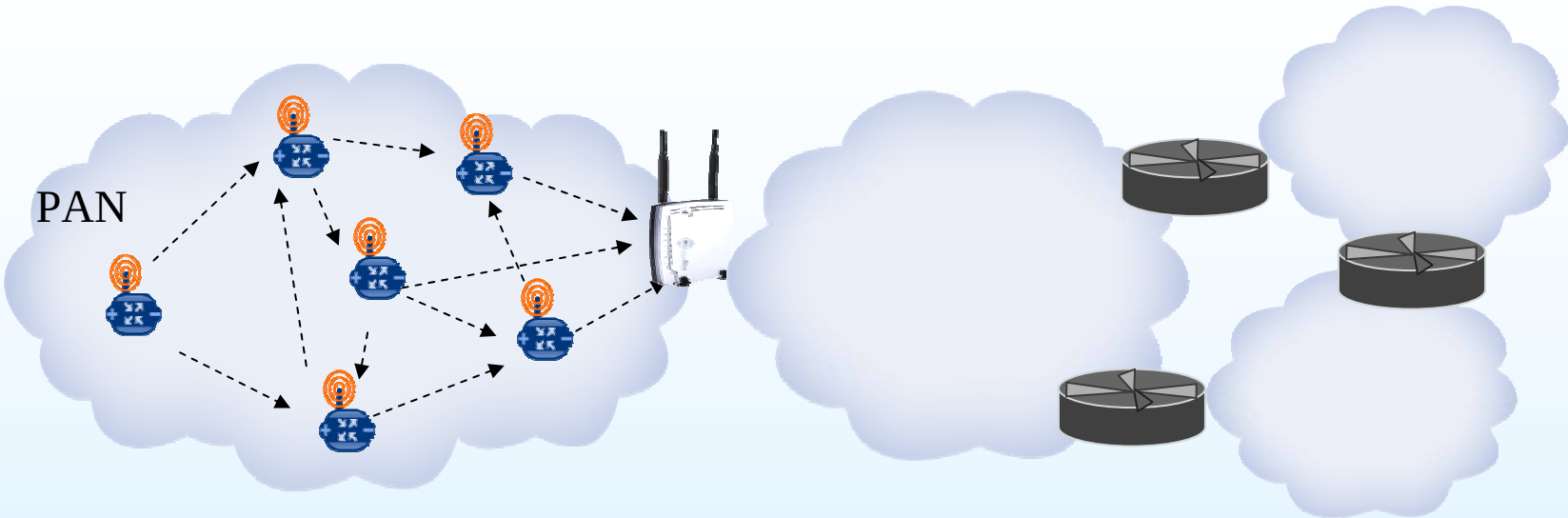
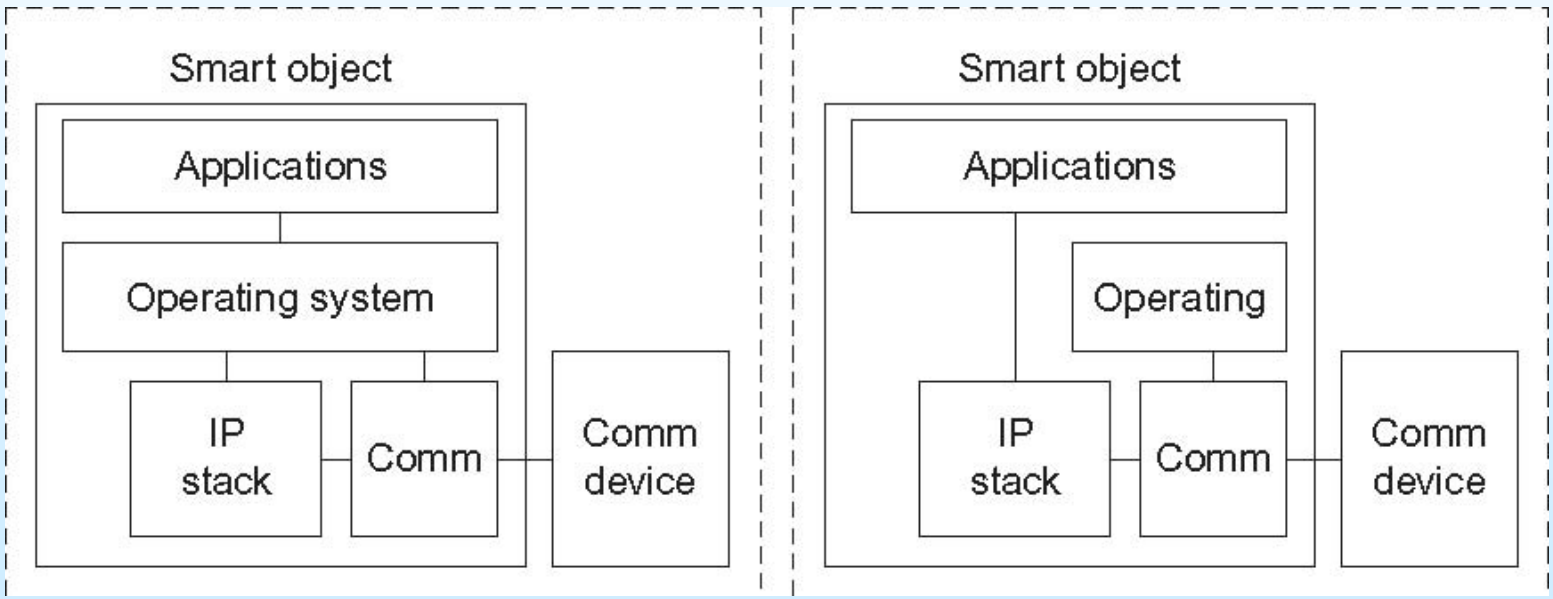
Multi-Hop Communication



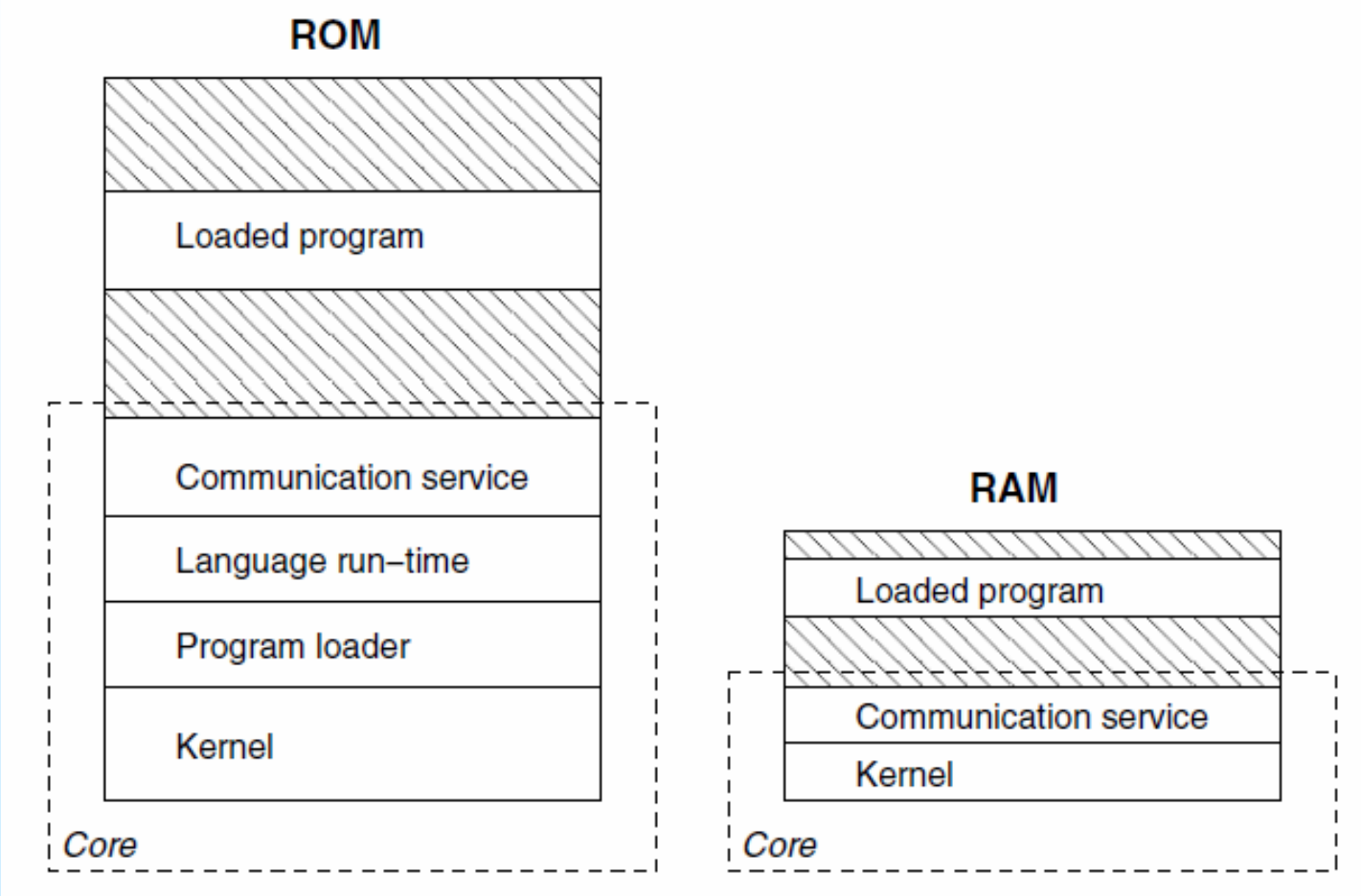
- Short-range radios & Obstructions => Multi-hop Communication is often required
  - i.e. Routing and Forwarding
  - That is what IP does!
- “Mesh-under”: multi-hop communication at the link layer
  - Still needs routing to other links or other PANs
- “Route-over”: IP routing within the PAN
- 6LoWPAN supports both

超轻量级的IP协议栈-uIP

- uIP(1KB RAM and 几KB ROM) Vs LwIP (40KB RAM，20KB ROM)
- Contiki Vs TinyOS
- uIP实现了网络的IP协议和传输层协议: IP, ICMP, UDP和TCP协议



支持IP的轻量级操作系统-Contiki



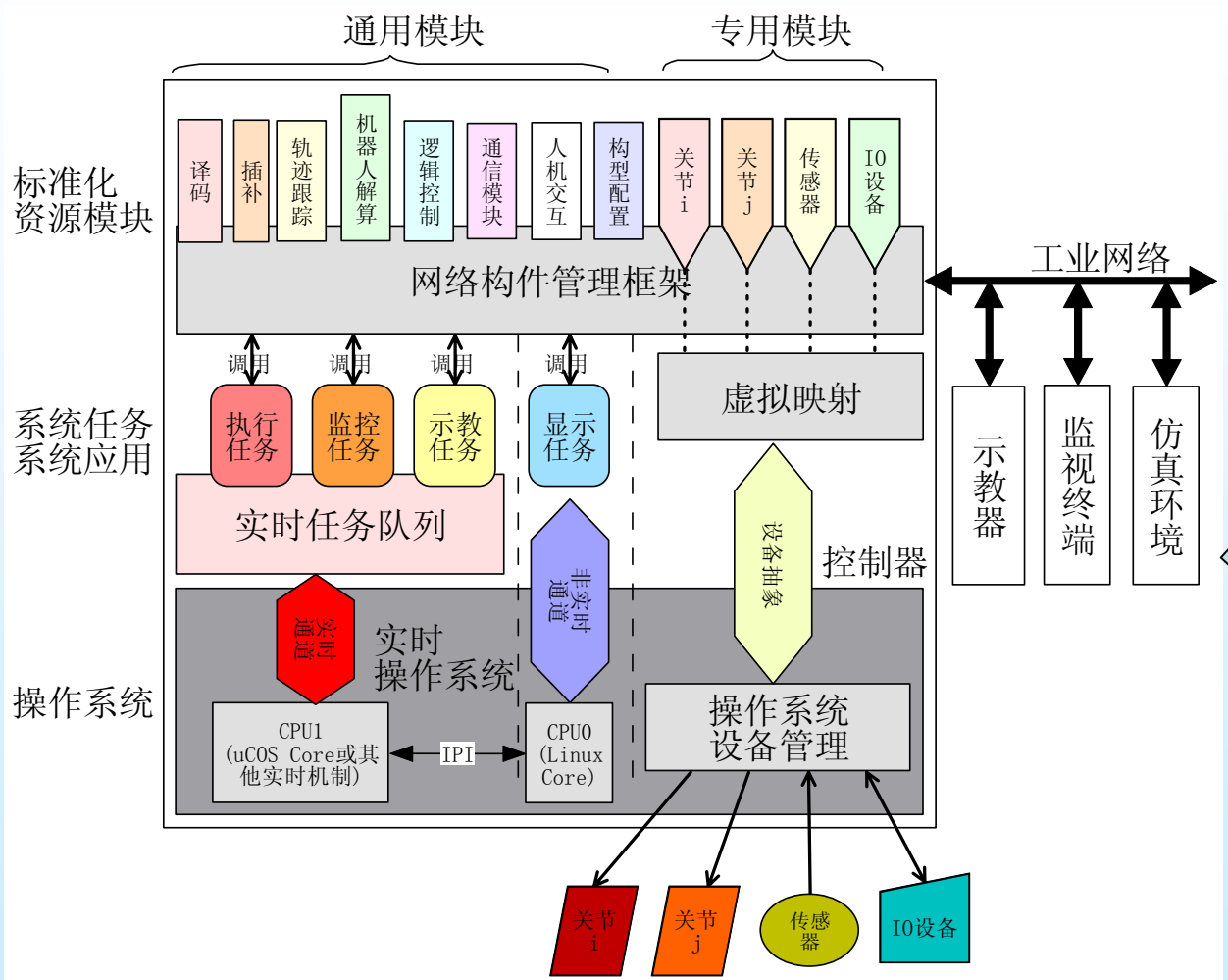
一种轻量级的协议栈——uIPv6

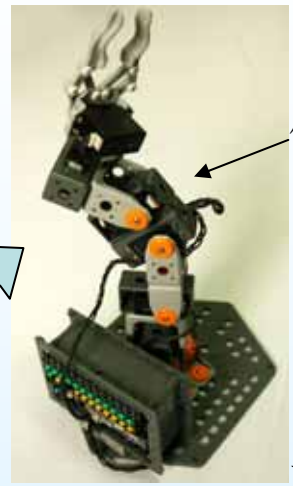
- **Contiki OS/UIP stack + KAME stack**

- **具有IPv6的全部功能：Code size ≈ 11.5 Kbyte，RAM usage ≈ 0.2+1.6 =1.8KByte;**

- **其它的实现：Archrock, Sensinode, PicosNet, Dust Networks, Gainspan, ZeroG, etc…**

基于IP的模块化机器人标准体系





低速总线
RobBus

高速总线
RobNet

*演示模块化功能部件、标准化、互换性

Q&A

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