

Image acquisition and Communication

Developements around the ACME Fox Board

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Outline

1 **Wireless Sensor Network (WSN)**

- What is a WSN ?
- Typical applications of WSN
- Purpose of this project

2 **Image acquisition and Communication**

- Embedded board: ACME Fox Board
- Image sensor acquisition
- Wireless PAN Communication

3 **Experimental results**

- Image transmission
- Bluetooth signal strength

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What is a WSN ?

Sensor

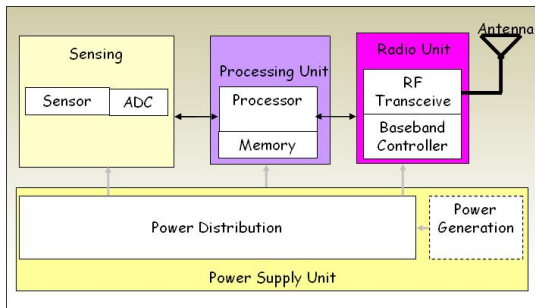
A device that responds to a stimulus, such as heat, light, or pressure, and generates a signal that can be measured or interpreted



Figure: Sonar

Components of sensor

Intelligent sensor



- Monitoring area
- Communication area
- Battery

Wireless Sensor Network

Characteristics

Sensor network is a large number of sensors devices which are able to collect and process information in different environment using wireless communication and transmit it to the base station known as *Sink*.

- Low cost and tiny sensor nodes
- Event detection
- Power limited
- Dynamic network topology
- Harsh environmental conditions
- Many to one

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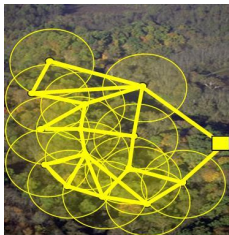
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Applications



- Factory equipment management
- Remote ecosystems monitoring
- Forest fire monitoring
- Earthquake detection
- Cold chain management

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WSN design

- Deployment
- Coverage of surface
- Data gathering
- Energy management

- Extended life-time
- Reliable communication
- Efficient integrated data processing
- Hybrid network infrastructure
- Security

Purpose of this work

Realization of a real sensor network and definition of a new protocol of communication considering sensors constraint

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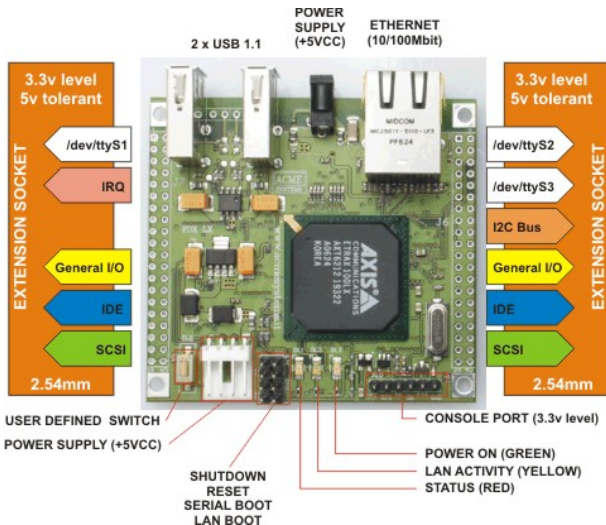
General Aspect

- Linux operating system on a *ETRAX 100LX* processor, a 100 MIPS RISC CPU made by Axis with MMU
- Open Source SDK supported by Acme Systems
- Advantages to develop on same operating system
- Fox LX: 4MB Flash and 16MB RAM
- Power supply: 5 Volt 280mA (lifetime on battery : 10 hours)
- Weight: 37 g Size: 66 x 72 mm
- USB Host and Serial link

Main field applications

- Stand alone device to build micro web server or other network devices
- Core engine to plug onto another board instead of a simple microcontroller

Technical Aspect



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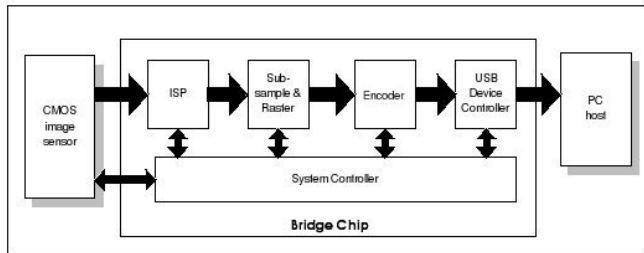
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USB Webcam device

Block diagram



Controlling Webcam

- Two drivers : PWC from *Luc Saillard* and SPCA5xx from *Michel Xhaard*
- Controlling webcam with Kernel API framework : *Video for Linux*
- Image compression from different color spaces (YUV, RAW, JPEG)

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Ubiquitous Computing Age

- Many wireless LAN product : Wifi, Bluetooth, Zigbee, . . .



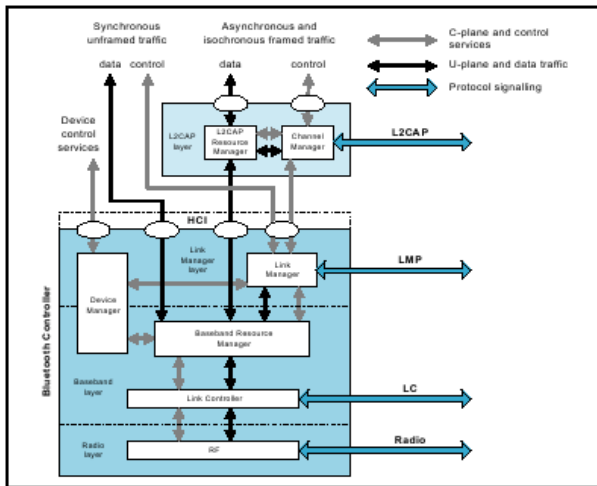
- Our choice **Bluetooth** : low consumption with short range on a low cost transceiver microchip based on a licence-free ISM band at 2.45GHz (720kb/s).
- Radio layer technique : **Frequency Hopping Spread Spectrum**(FHSS) system reduces interference of nearby systems operating on the same range of frequency, make link robust (79 channels)
- Modulation characteristics: Gaussian Frequency Shift Keying
- Many Bluetooth stacks : *BlueZ* (Qualcomm), *Affix* (Nokia), *BlueDrekar* (IBM), *OpenBTStack* (Axis)

- Bluetooth divided in 3 power classes:

Power Class	Maximum Output Power (P _{max})	Nominal Output Power	Minimum Output Power	Power Control
1	100 mW (20 dBm)	N/A	1 mW (0 dBm)	P _{min} ← +4 dBm to P _{max} Optional: P _{min} to P _{max}
2	2.5 mW (4 dBm)	1 mW (0 dBm)	0.25 mW (-8 dBm)	Optional: P _{min} to P _{max}
3	1 mW (0 dBm)	N/A	N/A	Optional: P _{min} ² to P _{max}

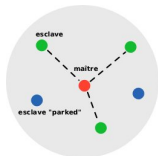
- Enhanced Data Rate in Bluetooth Specification V2.0 (Differential Phase Shift Keying Modulation), data rate of 2Mbps or 3Mbps.
- Packet oriented => 3 Logical Transports : SCO (Synchronous Connection-Oriented), ACL (Asynchronous Connection-oriented Link), eSCO. 15 different packet types in each logical transports.
- Link control packets : ID, NULL, POLL, FHS
- ACL packets : DM1, DH1, DM3, DH3, DM5, DH5, ...
- SCO packets : HV1, DV, EV3, 2-EV3, ...
- Error checking : HEC in header and CRC in payload
- Error correction: 1/3 rate FEC (Forward Error Checking), 2/3 rate FEC and ARQ (Automatic Repeat Scheme)

Bluetooth core system architecture



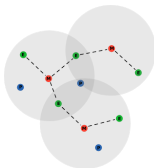
Bluetooth design

Bluetooth Piconet



Master-slave configurations/ Up to 7 active slaves
255 inactive (parked) slaves

Bluetooth Scatternet



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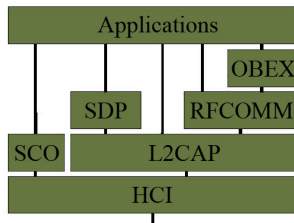
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Image transmission principle

Application features

- Protocol over **L2CAP** (Logical Link Control and Adaptation Protocol) layer in **ACL**
- Protocol over Obex layer (RFCOMM)
- Card doesn't store frames to reduce I/O operations on flash memory



HCI : Host Control Interface

Definition

HCI provides a command interface to the baseband controller and link manager and access to hardware status and control registers. This interface provides a uniform method of accessing the Bluetooth baseband capabilities.

Playing with HCI

- Each command : 2 bytes Opcode in 2 fields **OGF** 6 bits (Opcode Group Field) and **OCF** 10 bits (Opcode Command Field)
- Inquiry Opcode 01 04:

```
< 01 01 04 05 33 83 9E 08 00
> 04 0F 04 00 01 01 04
> 04 02 0F 01 3D 86 14 D9 0A 00 01 00 00 0C 22 10 59 43
> 04 01 01 00
```

L2CAP Protocol

Definition

L2CAP provides connection-oriented and connectionless data services to upper layer protocols with protocol multiplexing capabilities, segmentation and reassembly operation. L2CAP logical links supported by an ACL logical transports.

L2CAP communication

- **CID** (Channel Identifier) Logical Channel endpoint on the device
- **PSM** (Protocol/Service Multiplexor): SDP 01, RFCOMM 03. . .

```
static uint16_t psm = 0xaa79;
num_rsp = hci_inquiry (dev_id, length, num_rsp, NULL, &info, flags);
sock=socket(AF_BLUETOOTH, SOCK_SEQPACKET,
BTPROTO_L2CAP); . . .
```

How a piconet is established ?

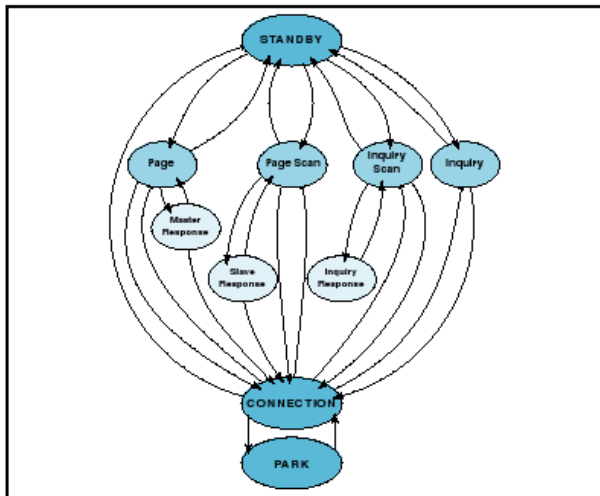
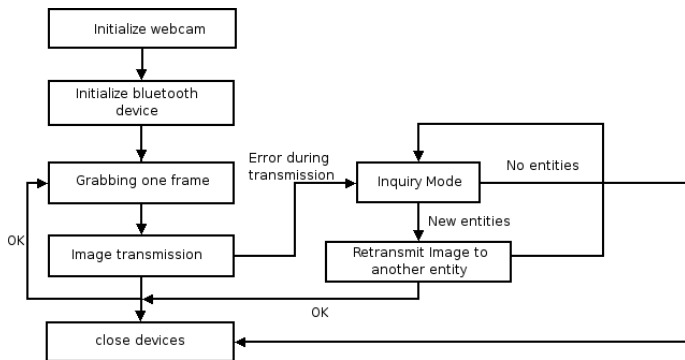
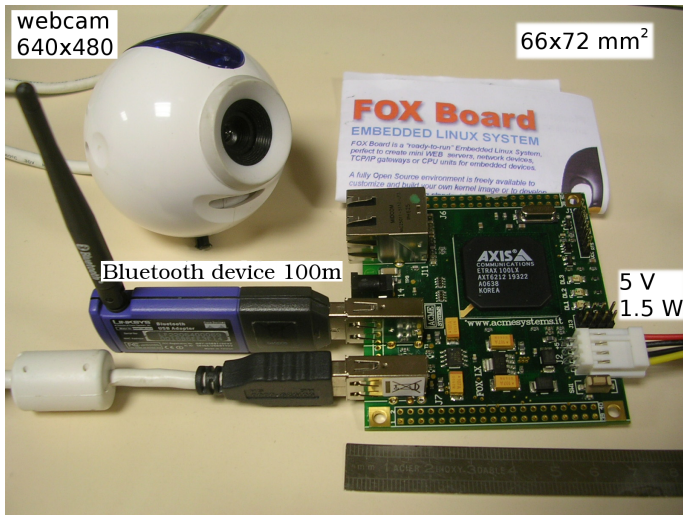


Image transmission principle



Fox card with webcam and bluetooth key



Who says a Fox card can't fly ?





- 10s/image
- Distance between Fox card and laptop : 35 meters

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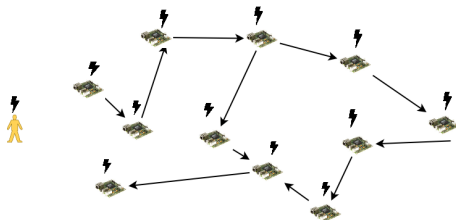
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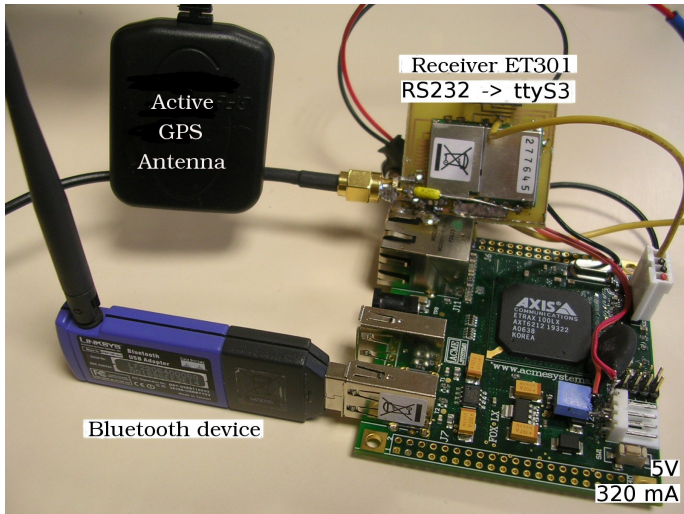
Fox card and Bluetooth experiment

Principle

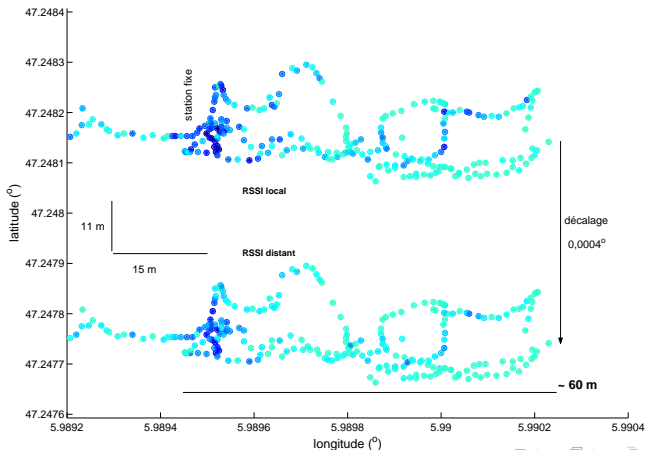
- Experiment in outdoor environment
- 2 measurements of the signal strength on a fixed device and a mobile Fox card
- Fox card with GPS receiver to answer to **Finding a relationship between the receiving signal strength and distance ?**



Fox card with GPS receiver ET301 and bluetooth



Bluetooth range and Receiving Signal Strength Indication (RSSI)




Summary

- Problem of Bluetooth reconnection
- Problem of scalability
- Communication between several Fox card
- Developpement of a new routing algorithms for WSN



Futher Reading I

 M. Ilyas Ed.,
The Handbook of Ad Hoc Wireless Networks.
CRC Press (2003)

 G. Weisenhorn, E. Pamba Capo-chichi, J-M. Friedt
*Communications de données et d'images issues de la carte Fox
par Bluetooth.*
Linux Magazine France (juin 2007)

Free Software Meeting: RMLL 2007



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