Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Zarlink response to 802.15 TG6 Call for Applications]
Date Submitted: [18 March, 2008]
Source: [Didier Sagan] Company [Zarlink]
Address [15822 Bernardo Center Drive, San Diego, CA 92127]
Voice:[+1 858 675-3400], FAX: :[+1 858 675-3450], E-Mail:[didier.sagan@zarlink.com]

Re: [n/a]

Abstract: [This document is Zarlink response to 802.15 TG6 Call for Applications]

Purpose: [This document is a response to P802.15 TG6 Call for Application on 18 Jan, 2008]

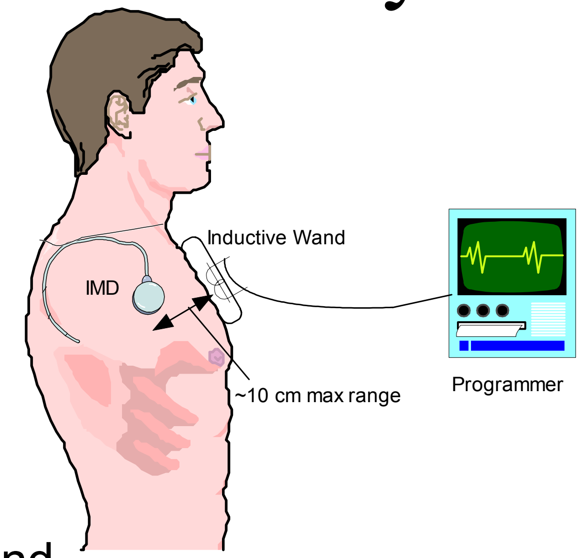
Zarlink response to 802.15 TG6 Call for Applications

Didier Sagan
Zarlink Semiconductor

Outline

- Implanted medical devices
  - The MICS Band
  - Applications for Medical Devices
  - Design Challenges
    - *Implantable Transceiver*
- In-vitro medical devices
    - *Swallowable Camera Pill Transmitter*
- Body worn medical devices
    - *ULP Transceiver for Hearing Aids*
- Conclusion

History – Implanted Medical Telemetry



- 1980s – Inductive Telemetry
  - Near field (sub 1 MHz) at data rates <50 kHz
  - Low power (<1 mA)
  - Pick up in implant using small coil
  - Very short range (10 cm max) requiring close skin contact
- 1999 – RF Telemetry
  - Medical Implant Communication Service (MICS) Band
  - 2003 Biotronik release MICS device (non-compliant)
  - 2004 Medtronic release MICS device
  - 2005 Guidant release ISM band (915 MHz) device
  - 2007 St-Judes release MICS device
  - ISM bands (13.56, 433, 868, 915 MHz) are sometimes used
- 2002 - Ultrasonic Telemetry

What is MICS ?

- Medical Implant Communication Service (MICS)
  - 402–405 MHz frequency allocation
    - FCC was petitioned in 1988, allocated in 1999
  - Short-range, wireless link to connect low-power implanted medical devices with monitoring and control equipment
    - Implanted Medical Devices (IMD) such as cardiac pacemakers, implantable cardioverter/defibrillator (ICD), neurostimulators, etc.
  - Why 402-405 MHz?
    - Reasonable signal propagation characteristics in the human body
    - Compatibility with incumbent users of the band (e.g. weather balloons)
  - General world-wide acceptance
    - Approved in United States, Europe, Canada, Australia and Japan

Why was MICS Introduced?

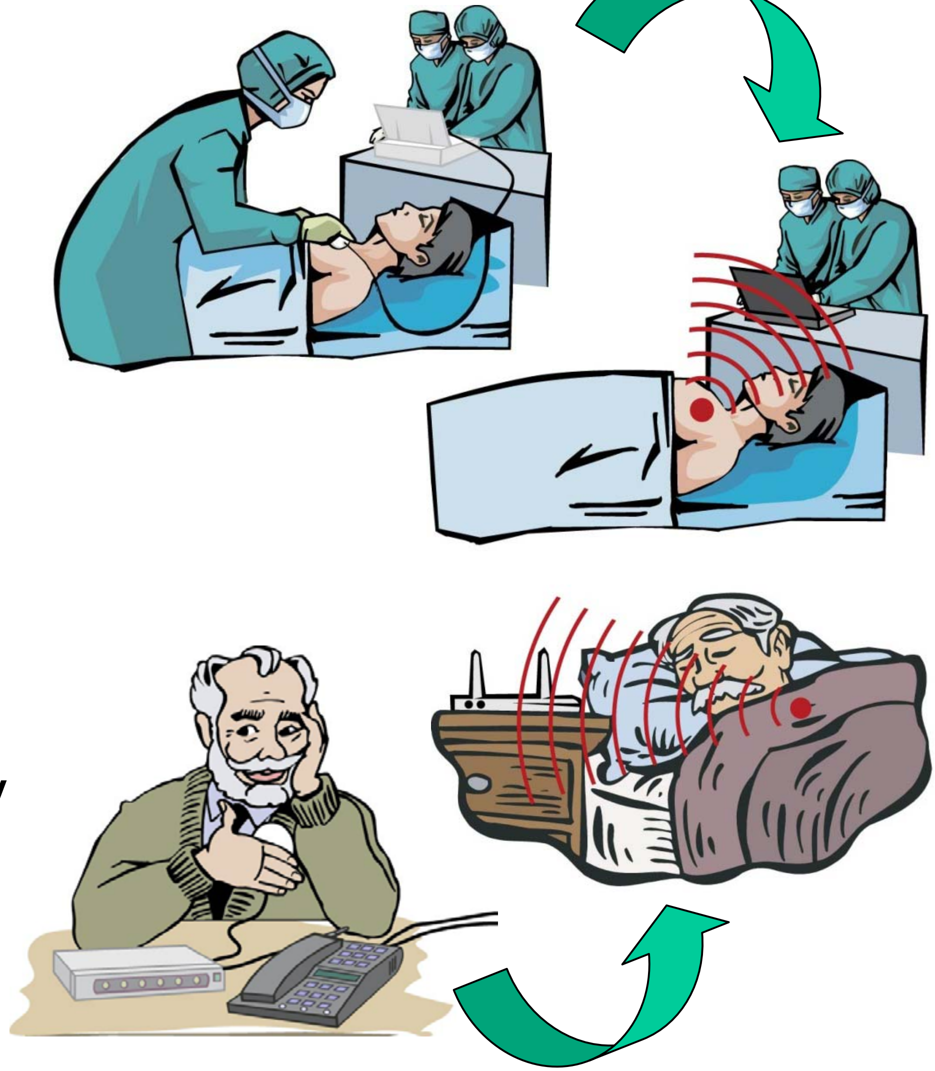
- Traditional telemetry not user friendly
  - Use inductive links
  - Very limited range
    - In contact with patient
  - Low frequency
    - Data rates similar to a dial-up computer modem
  - Not user friendly for home monitoring
    - Requires a wand to be positioned above the IMD by the patient

- Need for higher data rates
  - To upload patient events captured in the IMD's memory to the base station for analysis
  - Reprogram the IMD
  - Shorten doctor/patient consultancy times

Why was MICS Introduced?

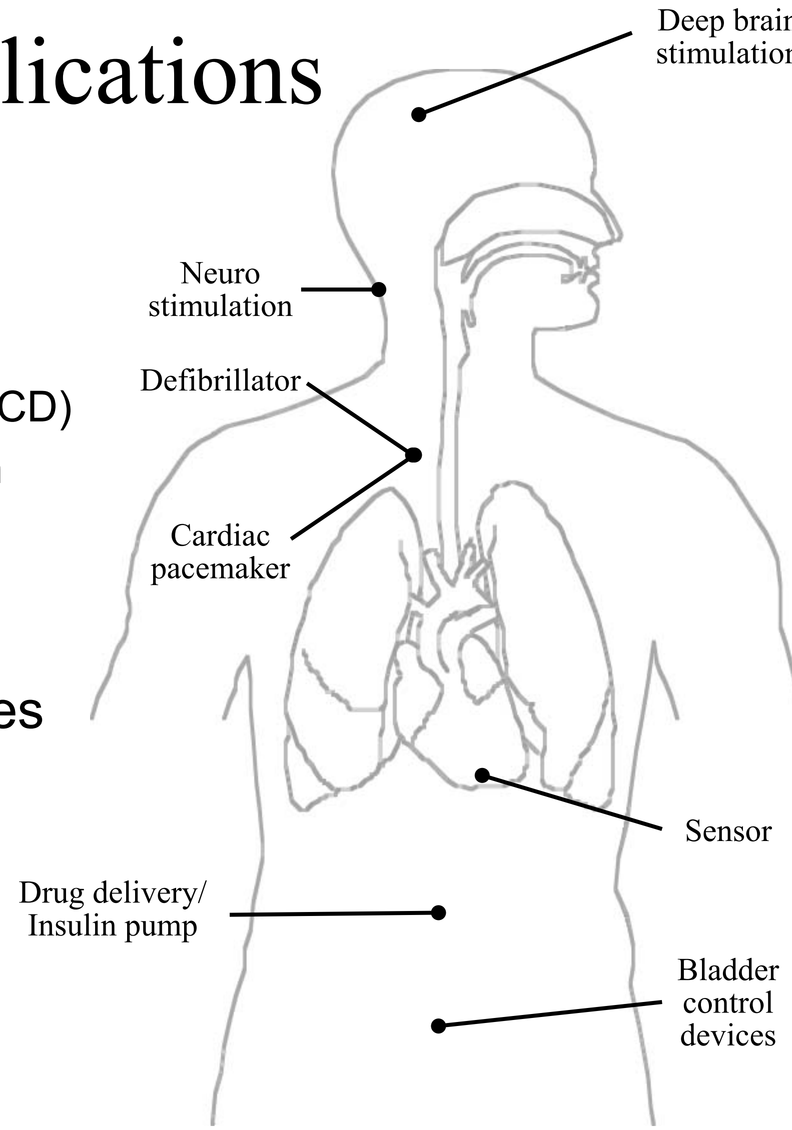
- Need for longer range
  - Locate the base station (programmer) outside of the sterile field during surgery
  - Simplify home-monitoring for elderly
  - Broaden possible applications
    - Bedside monitor for emergency

- Competitive pressures of the medical device industry
  - Higher data rates enable new, value-added services



MICS - Applications

- Stimulatory Devices
  - Pacemaker
  - Implantable Cardioverter/Defibrillator (ICD)
  - Neurostimulators and pain suppression devices
  - FES (Functional Electrical Stimulation)
- Measurement/Control/Other Devices
  - Drug infusion and dispensing
  - Artificial heart and heart assist devices
  - Implanted sensors
  - Control of other artificial organs and implanted devices

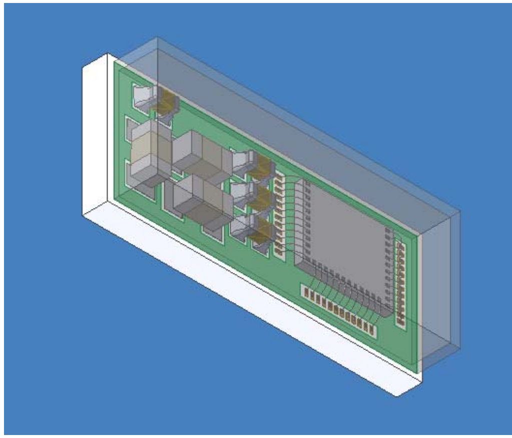


Challenges

- Ultra Low Power Consumption
  - Facts about implanted pacemakers
    - Lifetime > 7 years; up to 10 years
    - Maximum current drain of the order of 10 – 20 uA
    - Telemetry budgeted as no more than 15%, i.e. 2 – 3 uA
    - Telemetry is off most of the time but still need to sniff every 1 – 10 s
    - Consumption during Sleep/Sniff modes is therefore the most critical
  - Requirements
    - Very low TX/RX current, <15nA.s/bit
    - Ultra low sleep/listen current, ideally <100s of nA
    - Implies leakage <100nA (at body temperature)

Challenges

- Minimum External Components
  - RF module <3x5x10 mm
  - Fewer components => higher reliability, lower cost, smaller size
- High data rates
  - Need to go beyond current payload requirements
  - Sending data in short bursts conserves power
  - Reduces time window for interference and easier supply decoupling
- Operating range
  - Require ~2 m outside the body to improve on existing links (short range inductive)
  - Antenna matching, fading and body loss typically 40-50 dB
- Reliability
  - Data and link integrity, selectivity and interference rejection
  - Need to work 24/7 for 10 years; no reset button…

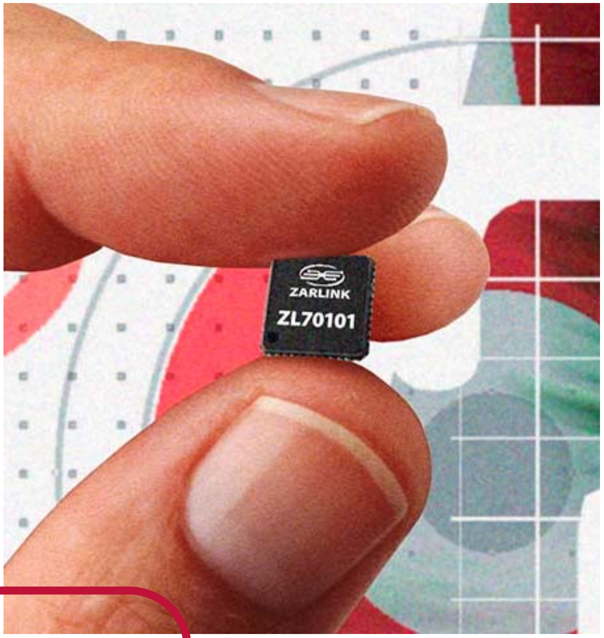


Module size 3 x 5 x 10 mm

ULP Implantable Transceiver

MICS and ISM Band Transceiver:

- Negligible standby current
- high data and low error rates in a small footprint

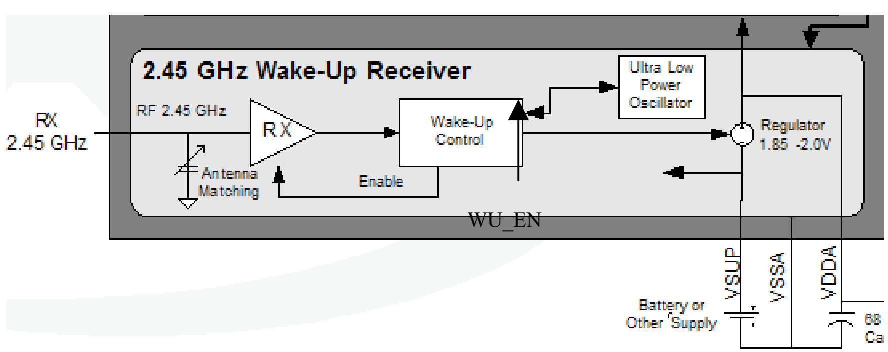


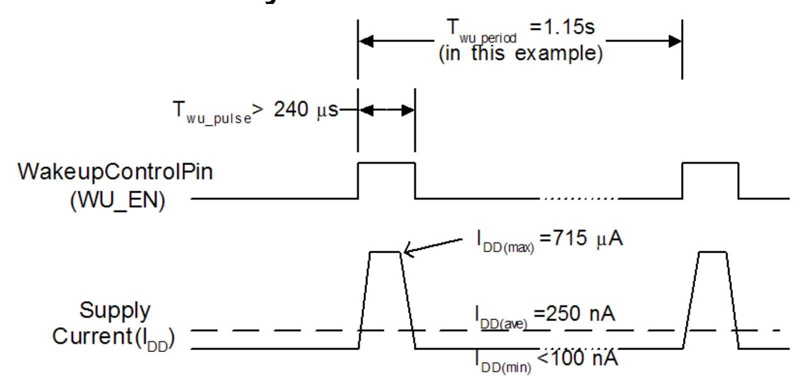
ZL70101:

Supply Voltage:	2.1 - 3.5 V Battery
Radio Frequency:	402-405 MHz / 433 MHz
Type of RF link	Bi-directional, half duplex
Modulation Scheme:	FSK
Raw Bit Rate:	800 / 400 / 200 kbits/s
Operating Current:	5mA TX/RX down to <1mA
Sleep (sniff) Current:	< 250 nA
Ext. comps:	3 (2 caps, Xtal) + antenna matching)
BER:	$< 1.5 \times 10^{-10}$
Range:	~2 m
Interface:	SPI

Wakeup

- Problem: MICS band limited to 25 uW (-16 dBm)
- Consequence: Very small received signal
  - Receiver power too large to meet both latency and power consumption requirement in sniff mode.
- One solution: Use band with more power 2.45 GHz (up to 20 dBm) and design a synthesizer-less receiver
  - 250 nA average current for 1.15 second latency





The Camera Pill

(Company: Given Imaging)

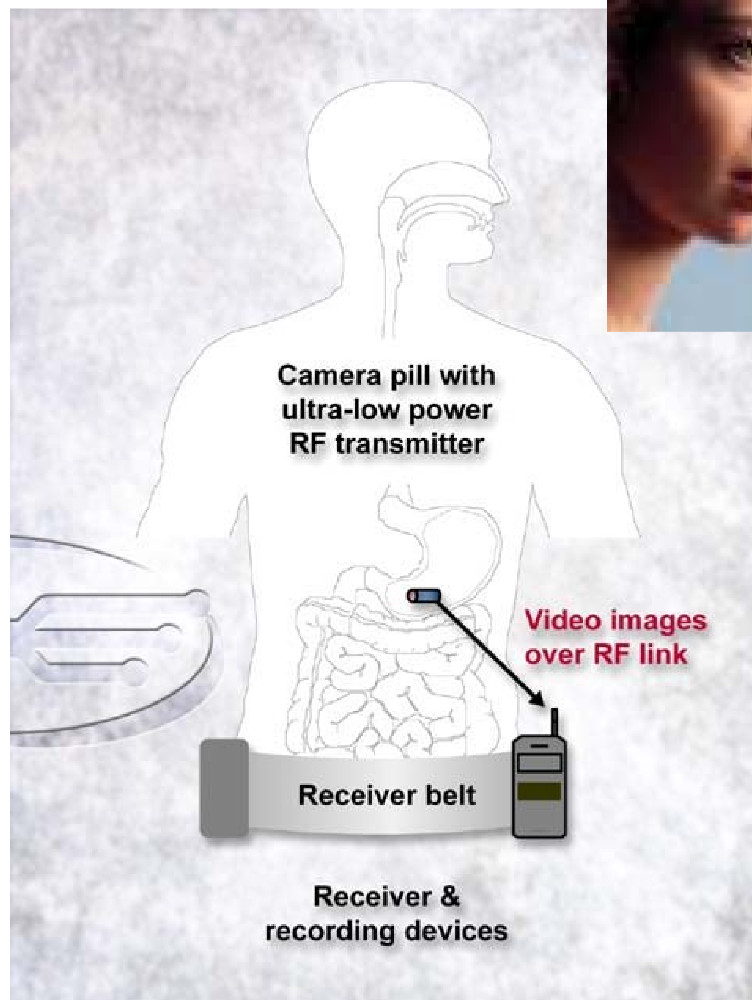
New digestive track diagnostic tool

Replace traditional endoscopy

Better diagnostic

3D mapping capability

Healthy Small Bowel



The Camera Pill - Facts

Size: 11 x 26 mm

Weight: < 4 gram

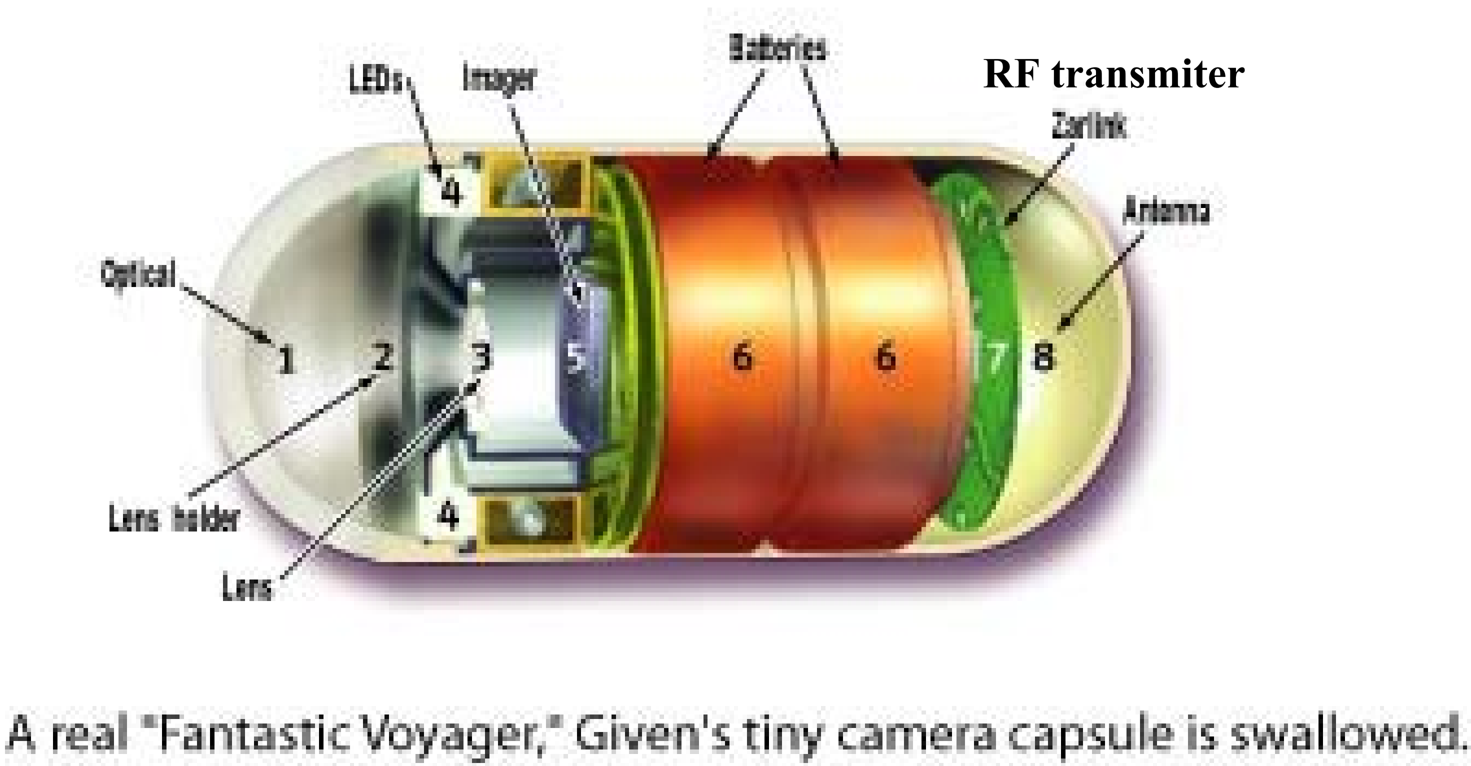
View: 140 deg

Approximately 57,000 pictures

During 8 hours

The Camera Pill – The Inside

- World's First Swallowable Camera Capsule, from Given Imaging, including Zarlink's ULP RF Transmitter

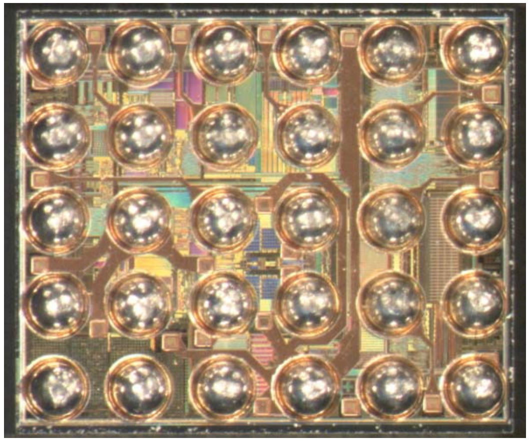


ULP Medical Transmitter

Very high data rate transmitter

- very low power
- small footprint
- designed for imaging applications

Supply Voltage	2.6 - 3.2 V Battery
Radio Frequency:	400 - 440 MHz
Type of RF link:	Transmit only
Bit Rate:	2700 kbits/s
Operating Power:	5.2 mW
Ext. comps:	10



Hearing Aids are becoming Communication Devices

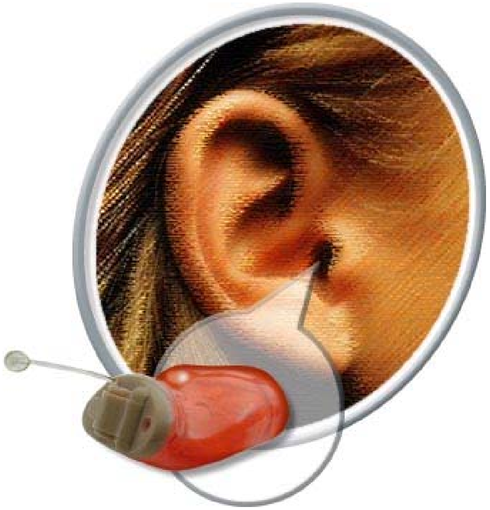
- Programming would be easier, more reliable and cheaper without cable.
- Ear-to-ear communication can improve hearing by coming closer to providing a real stereo image.
- Streaming audio allow connection to cell phone and MP3 player.

- But power consumption is limited
  - HA need to last 1 – 2 weeks, 16h/day
  - Battery capacity is limited (typ ~250 mA.h, 1.25V)
  - Battery chemistry limits peak current (few mA)
  - HA functionality is ~1mA
  - Wireless link budget should be < 25%

Physiology Monitoring

- Many different use cases
  - Clinical environment
  - Home monitoring (chronical disease, health status)
  - Fitness
  - Animals (Lab test, pets & live stock)
- Parameters:
  - HR, Temp, BP, ECG, EEG, SpO2, Plethysmography, etc.
- Usage model:
  - Spot measurements vs Continuous monitoring
  - From few days to few months to few years
- Number of sensors: 1 to 6
- Payload:
  - From few bits/s up to 5 kbps per sensor
  - Aggregate: up to 10-15 kbps
- In some cases a wireless node would need ~10kbps, operating continuously 24/7 for months without changing the battery.
  - Wireless telemetry needs an efficiency better than 15nJ/bit

ULP ISM Transceiver



Requirements:

- Smallest possible peak power
- Data rate that supports audio streaming
- Very efficient (11nJ/bit in both Tx and Rx)
- Very small

ZL70250:

Radio Frequency:	**915 MHz (Americas) / 863-865 MHz (Europe)**
Type of RF link:	**Bi-directional, half duplex**
Bit Rate:	**186 kbits/s**
Current Consumption:	**2 mA from 1.05 - 1.5 V Battery**
Range:	**3 meters (limited by antenna size)**
Externals:	**2 (Xtal,Res)**
Interface:	**SPI + 2-wire**

Comments about antennas

- Assumption that antenna size shrinks with higher frequency is not always true
  - For given range and path loss, antenna size remains about the same
  - In other materials than air, the practical antenna type vs freq combinations can compensate or even reverse the relation.
- The dipole is not the best antenna near the body
  - A dipole, like any electro-magnetic antenna, is detuned by the body
  - An electrically small loop is behave as a magnetic antenna and is very little affected by the body
  - But electrically small loops are not practical for GHz frequencies
- Practical example:
  - 25mm x 10mm loop at 900MHz
  - Built on FR4 PCB: very cheap and repeatable
  - -5dBi antenna gain
  - Not affected by pinching it while same (crude) test with a dipole resulted in significant radiation loss.

Conclusion

- RF telemetry in and around the body already exists. There are commercial parts available to support such applications

- For implanted telemetry, most of the industry has chosen to use the MICS band.

- Most ‘around the body’ applications use a proprietary solutions, often by choice (seen as a competitive differentiator)

- Enabling parameter: ULP power consumption