Architecture and Evaluation of
INGA – Inexpensive Node for General Applications

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What are we dealing with in Germany?
What the hell is GAL?

German Project “GAL”

G estaltung
A ltergerechter
L ebenswelten

“Design of Environments for Aging”

- Research project
- Funded by the state of Lower Saxony
- Interdisciplinary approach
Use Cases / Scenarios

Exemplary Assisting Systems

1. Personal activity and household assistant
2. Monitoring of sports activities in prevention and rehabilitation
3. Sensor-based activity determination
4. Sensor-based fall prevention and fall recognition
Body Area Network - Monitor Activity of Elderly People

Detect Falls
Monitor Gait
Determine Activity

- Activity data gathered from various sensors
  - Accelerometer (3 axis)
  - Gyroscope (3 axis)
  - Pressure Sensor

→ Nobody did this in combination, yet...
Related Products: Freescale RD3152MMA7260Q

Freescale RD3152MMA7260Q: Wireless Sensing Triple Axis Reference Design (ZSTAR)

- Microprocessor: MC9So8QG8
  - 512 Bytes RAM
  - 8 KBytes FLASH
- Transceiver: MC1319x
- No SD-Card Slot
- Accelerometer: MMA7260QT
  - Only sensor

- Price: 111 €
  - No longer manufactured
Related Products: Shimmer Sensor

Shimmer Sensor

- Texas Instruments MSP430F1611
  - RAM: 10KB
  - Flash: 48KB
- IEEE802.15.4 cc2420 Transceiver
- Bluetooth RN-42
- SD Card Slot
- Accelerometer: Freescale MMA7361
- Price: 199 € (basic variant),
  - + 219 € (kinematic daughterboard)
  - + 199 € (programming unit)
- No Pressure sensor available
Related Products: SenseWear Armband

Commercial Product
- No technical information available
- 2-axis Accelerometer, 32 Hz sampling rate
  - + Temperature Sensor
  - + Galvanic Skin Response
- Proprietary wireless connection
- Battery-Power: „up to 7 days“
- Memory: „up to 14 Days recording“
- Price: starting from 1.023,40 €
Body Area Network - Monitor Activity of elderly people

Detect Falls, Monitor Gait

- Activity data gathered from various sensors
  - Accelerometer
  - Gyroscope
  - Pressure Sensor

No existing nodes fulfilled the requirements

- Combine advantages from existing ones
- Build a “new” sensor node

⇒ INGA

- Inexpensive Node for general Applications
Architecture of INGA

- Based on ATmega 1284p MCU
- Atmel AT86RF231 RF-Transceiver, printed PCB antenna
  - 2.4 GHz, IEEE802.15.4 / ZigBee, Hardware AES
- USB / UART (FTDI) for programming
Architecture of INGA

- Li+ charger for Li-Ion or Li-Po battery
- Power monitoring (voltage and current)
- User switch and user LEDs
- Pin headers (2.54 mm) for all relevant signals and busses
**I²C Bus: Gyroscope**

**Gyroscope L3G4200D (ST Microelectronics)**

- 3 axis digital, 16 bit resolution
- Up to 2000° per second
- Integrated temperature sensor (8 bit)
Pressure Sensor BMP085 (Bosch)

- Resolution of 0.01 hPa (16 – 19 bit)
- Accuracy of 0.2 hPa
- Included temperature sensor (16 bit)
1-of-8 Demultiplexer

- 3 I/O-lines for up to 7 devices on MSPI bus
- Flash Memory AT45DBxx1 (Atmel)
- Dual buffer interface
- 8 to 32 Mbit capacity

(M)SPI-Bus: Flash Memory and Demultiplexer
Accelerometer ADXL345 (Analog Devices)

- 3 axis digital
- 2g, 4g, 8g and 16g at 10 to 13 bit
- Up to 3.2kHz sampling rate
Socket for Micro-SD Card

- Operation via SPI-Mode (slow, but sufficient)
- Disconnect all lines via Tri-State-Buffer
  - No power drain through signal lines
Exemplary Evaluation: INGA vs. TMote Sky – UDP Throughput

![Graph showing UDP throughput comparison between INGA and TMote SKY.](image)
Exemplary Evaluation: INGA vs. TMote Sky – Power Consumption

- Power consumption depends on what you do
- All sensors can be set to power saving states

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<tr>
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<th>INGA</th>
<th>TMote Sky</th>
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<tr>
<td>$I_{cc}$</td>
<td>18.69 mA</td>
<td>19.69 mA</td>
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<tr>
<td>Max. transmit rate</td>
<td>125.98 Kbit/s</td>
<td>90.91 Kbit/s</td>
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<tr>
<td>Electric Charge</td>
<td>0.15 mAs per bit</td>
<td>0.22 mAs per bit</td>
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Exemplary Evaluation: Memory Access

- Flash (directly)
- SD-card (with buffer)
- SD-card (directly)

![Graph showing memory access performance metrics](image-url)
Current State & Ongoing Work

150 INGA devices built
- Student lab – very interesting projects

Field study “Activity Monitoring”
- Begins in a few months

Operating System Support
- Contiki
- TinyOS
- WiseLib
Summary and Conclusion

INGA is

- Open Source
- Cheap and easy to expand
- Running Contiki and TinyOS out of the box

Use it:


Thanks for the attention!

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