



Technische  
Universität  
Braunschweig

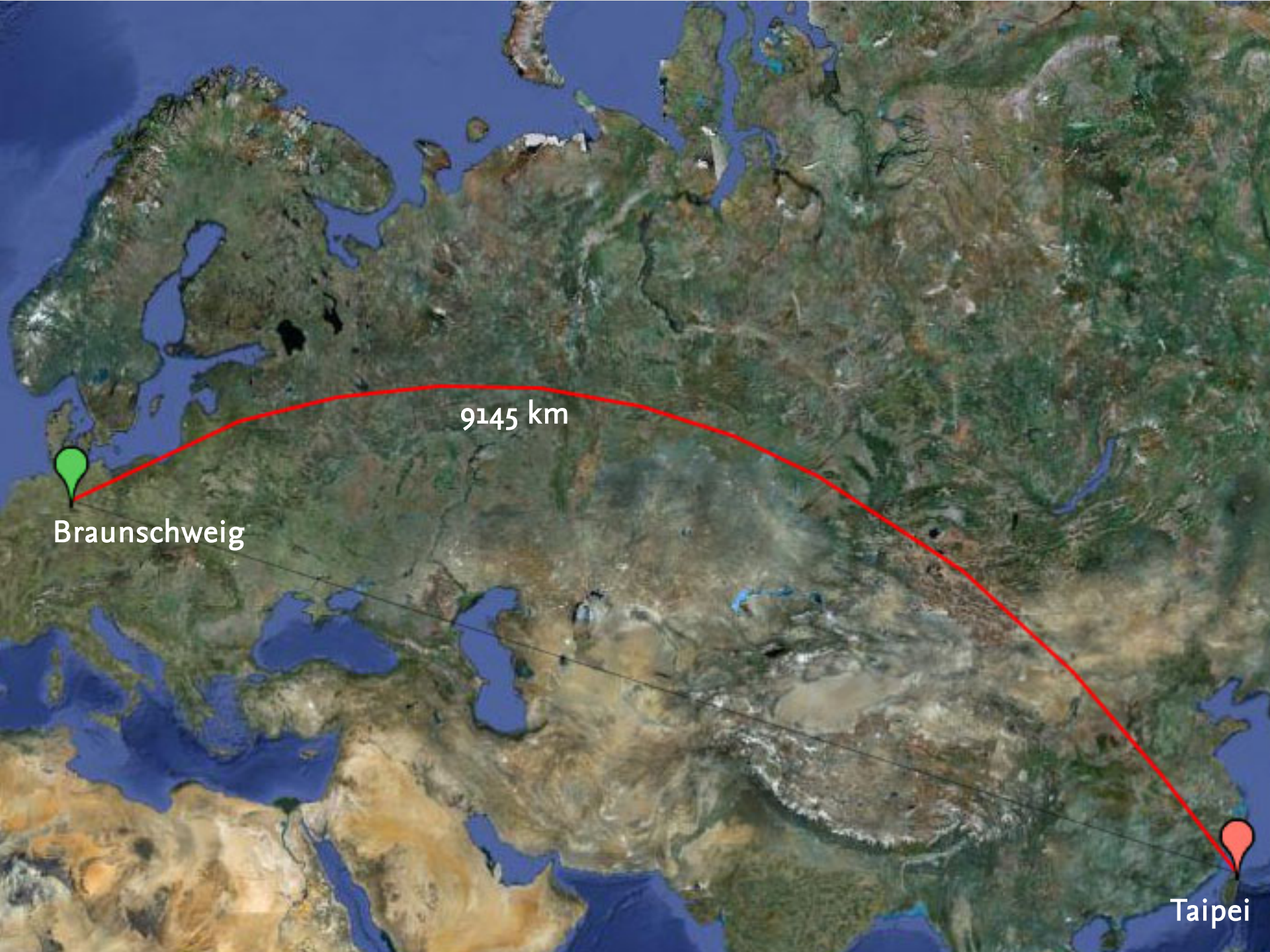
Institute of Operating Systems  
and Computer Networks



## Architecture and Evaluation of INGA – Inexpensive Node for General Applications

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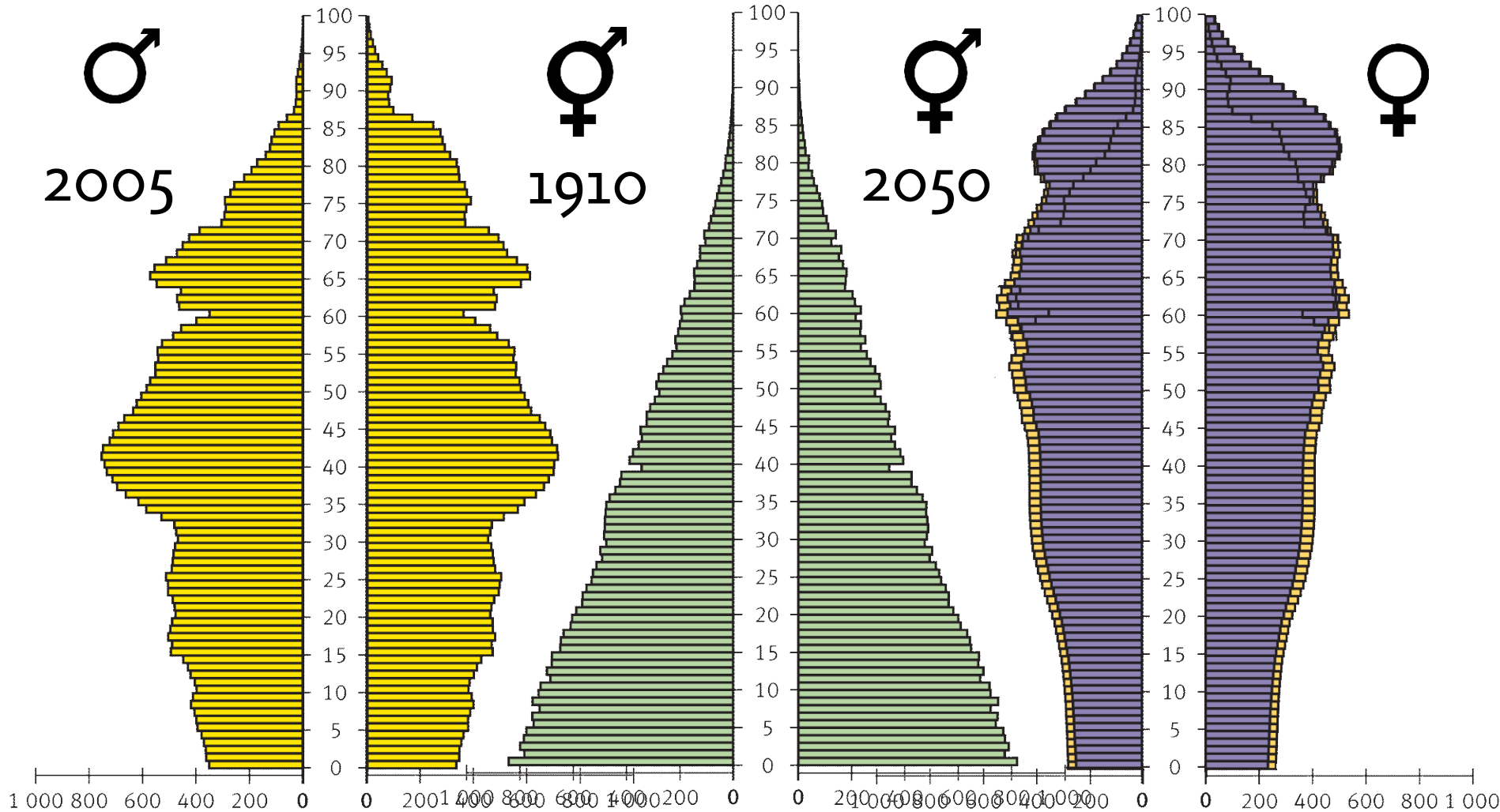


Braunschweig

9145 km

Taipei

# What are we dealing with in Germany?



# What the hell is GAL?

## German Project “GAL”

Gestaltung

Alternergerechter

Lebenswelten

## “Design of Environments for Aging”

- Research project
- Funded by the state of Lower Saxony
- Interdisciplinary approach

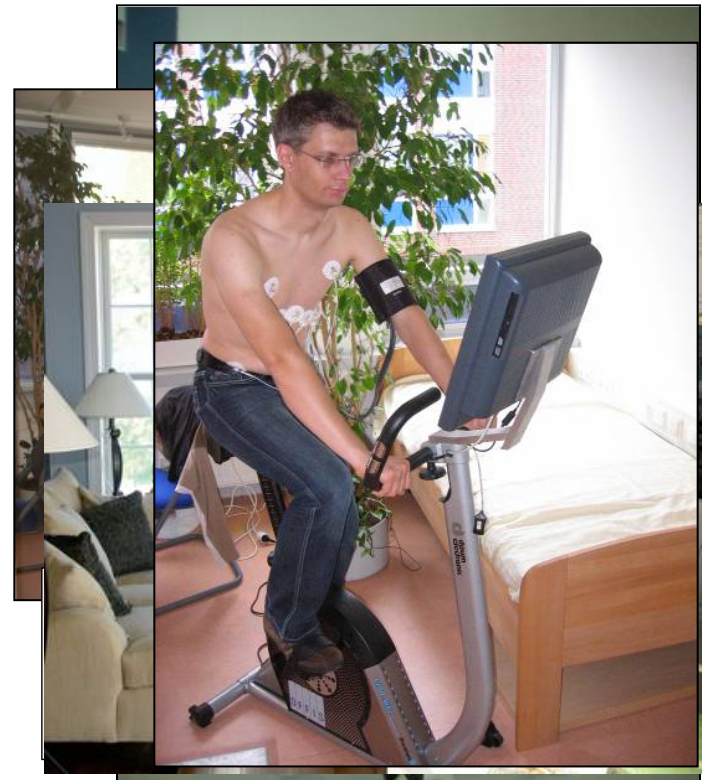




# Use Cases / Scenarios

## 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

Body Area  
Network

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

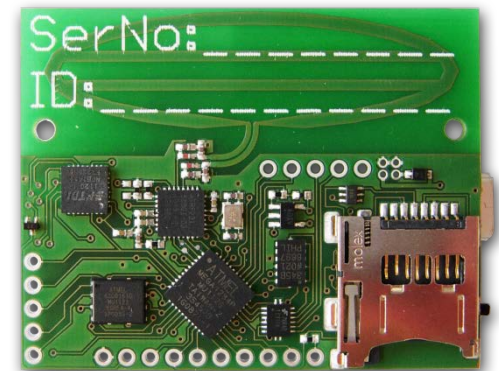
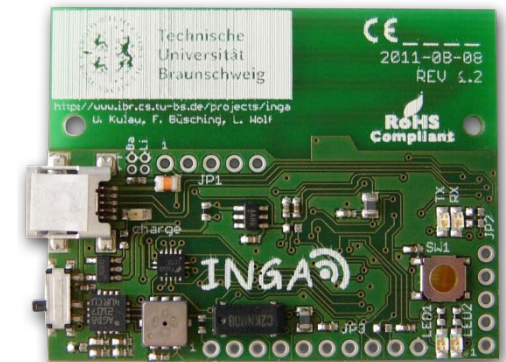
Body Area  
Network

## Detect Falls, Monitor Gait

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

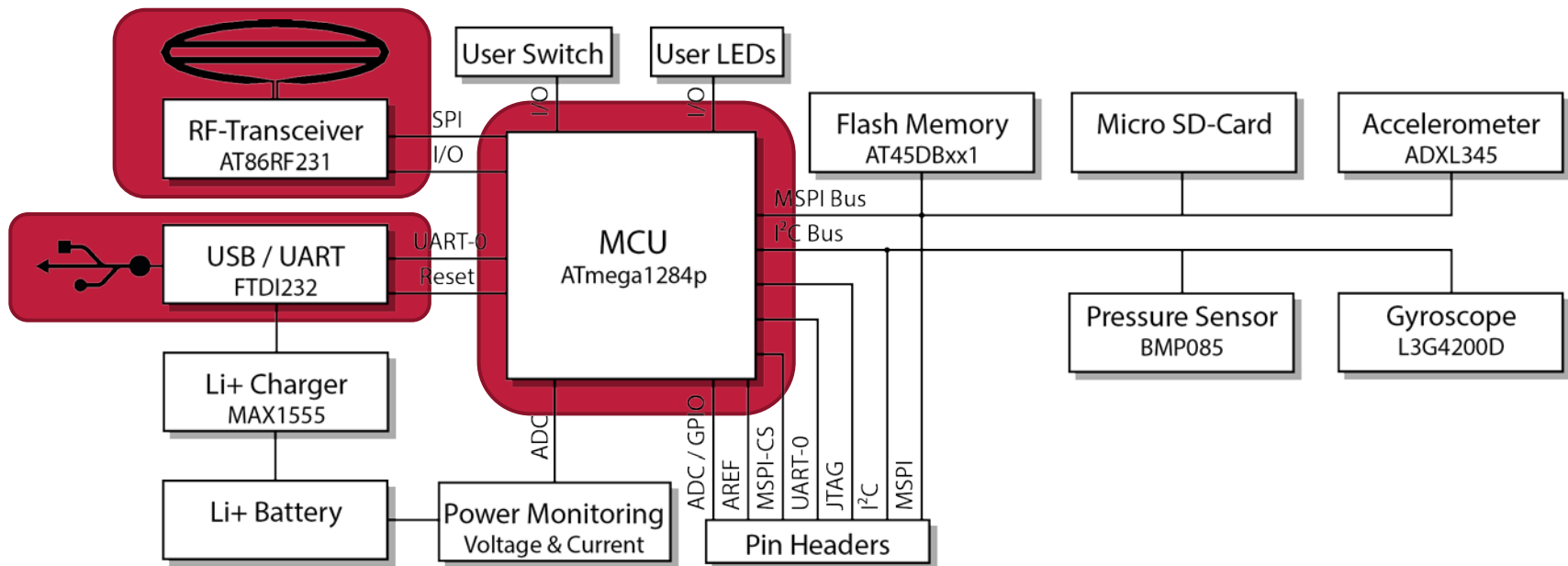
## No existing nodes fulfilled the requirements

- Combine advantages from existing ones
  - Build a “new” sensor node
- ➔ INGA
- Inexpensive Node for general Applications



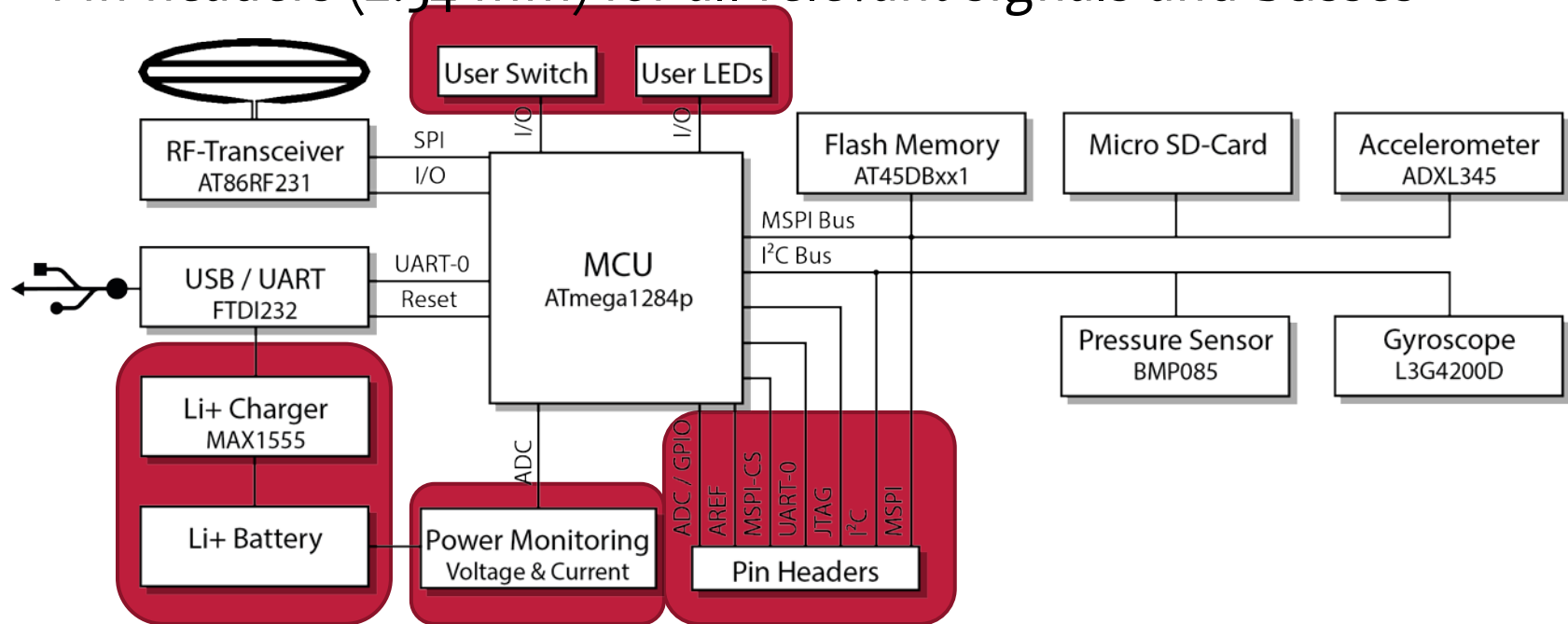
# Architecture of INGA

- 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

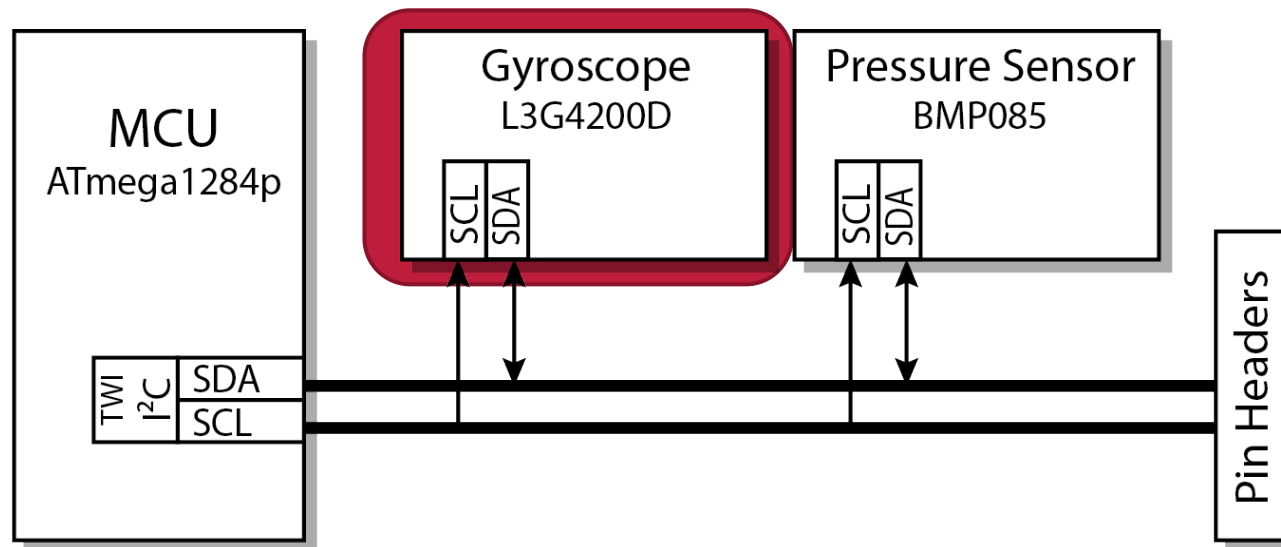




# I<sup>2</sup>C Bus: Gyroscope

## Gyroscope L3G4200D (ST Microelectronics)

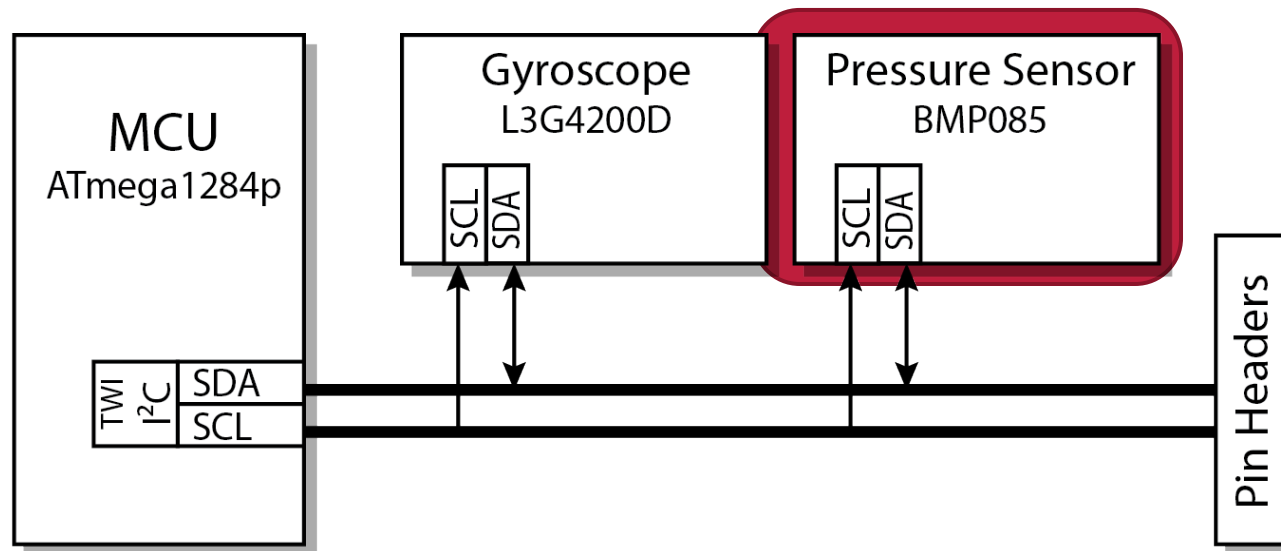
- 3 axis digital, 16 bit resolution
- Up to 2000° per second
- Integrated temperature sensor (8 bit)



# I<sup>2</sup>C Bus: Air Pressure Sensor

## Pressure Sensor BMP085 (Bosch)

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



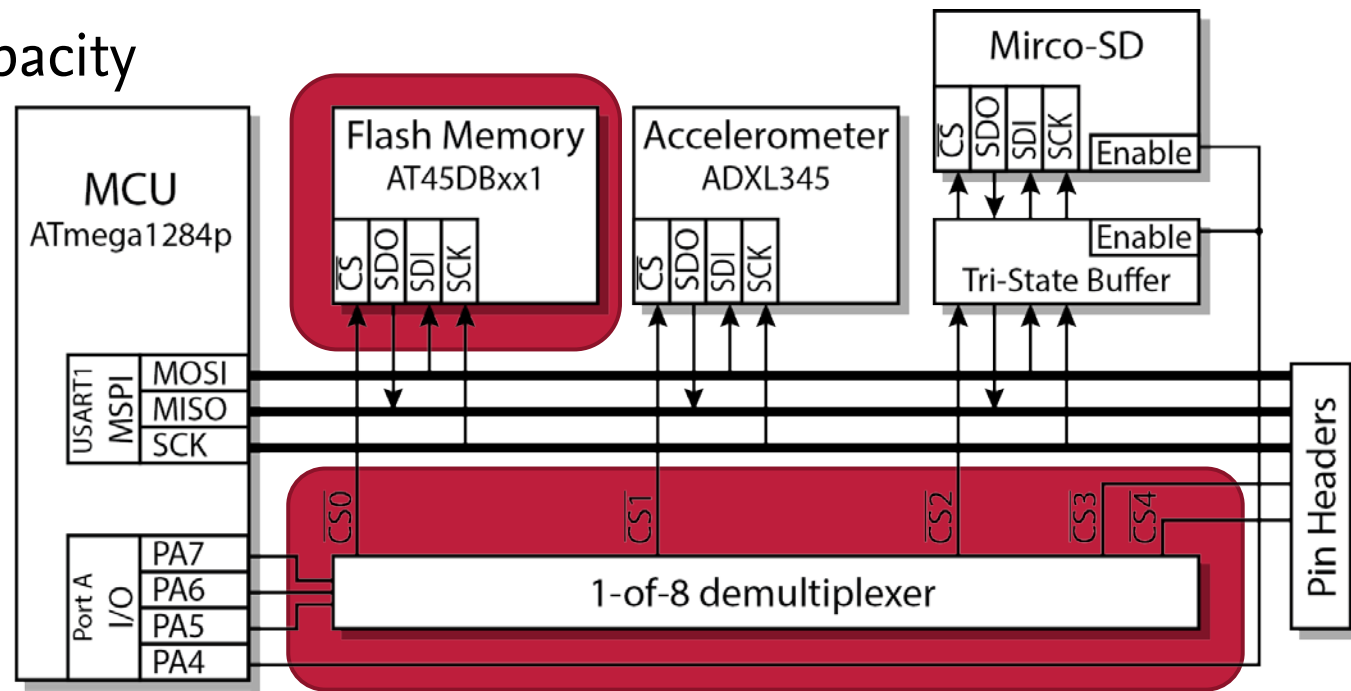
# (M)SPI-Bus: Flash Memory and Demultiplexer

## 1-of-8 Demultiplexer

- 3 I/O-lines for up to 7 devices on MSPI bus

## Flash Memory AT45DBxx1 (Atmel)

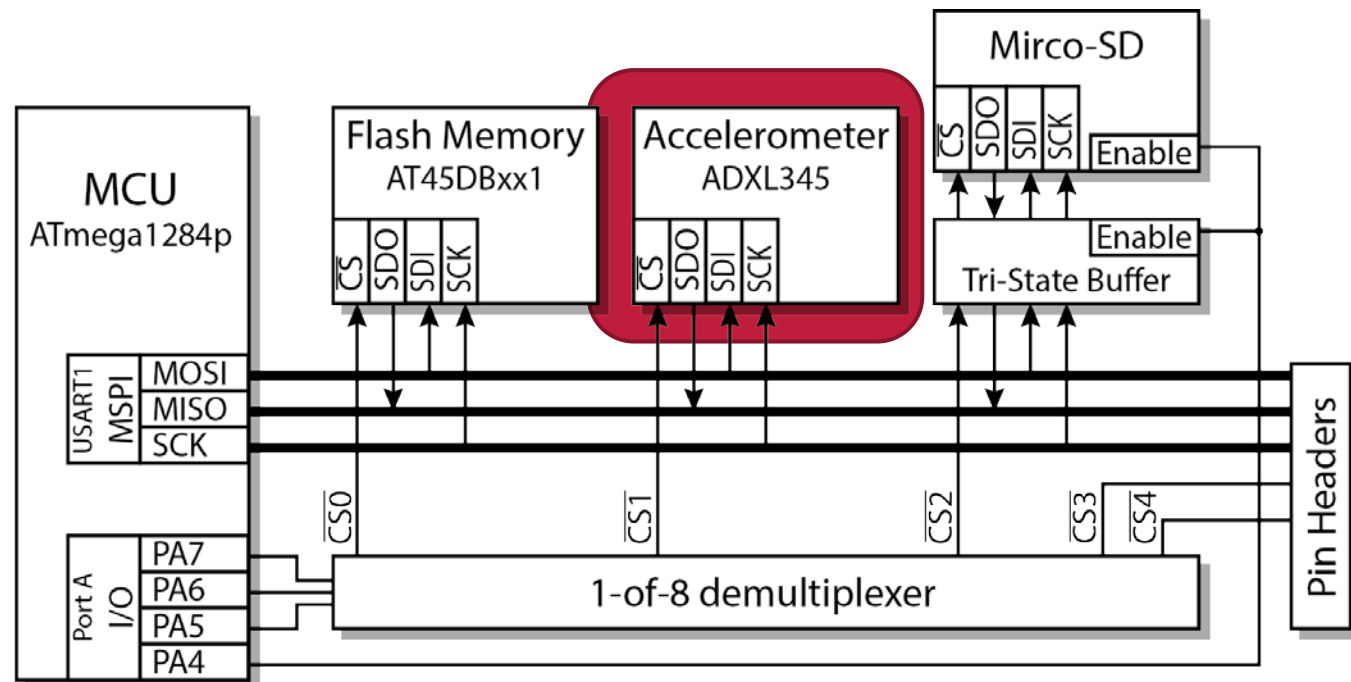
- dual buffer interface
- 8 to 32 Mbit capacity



# (M)SPI-Bus: Accelerometer

## Accelerometer ADXL345 (Analog Devices)

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

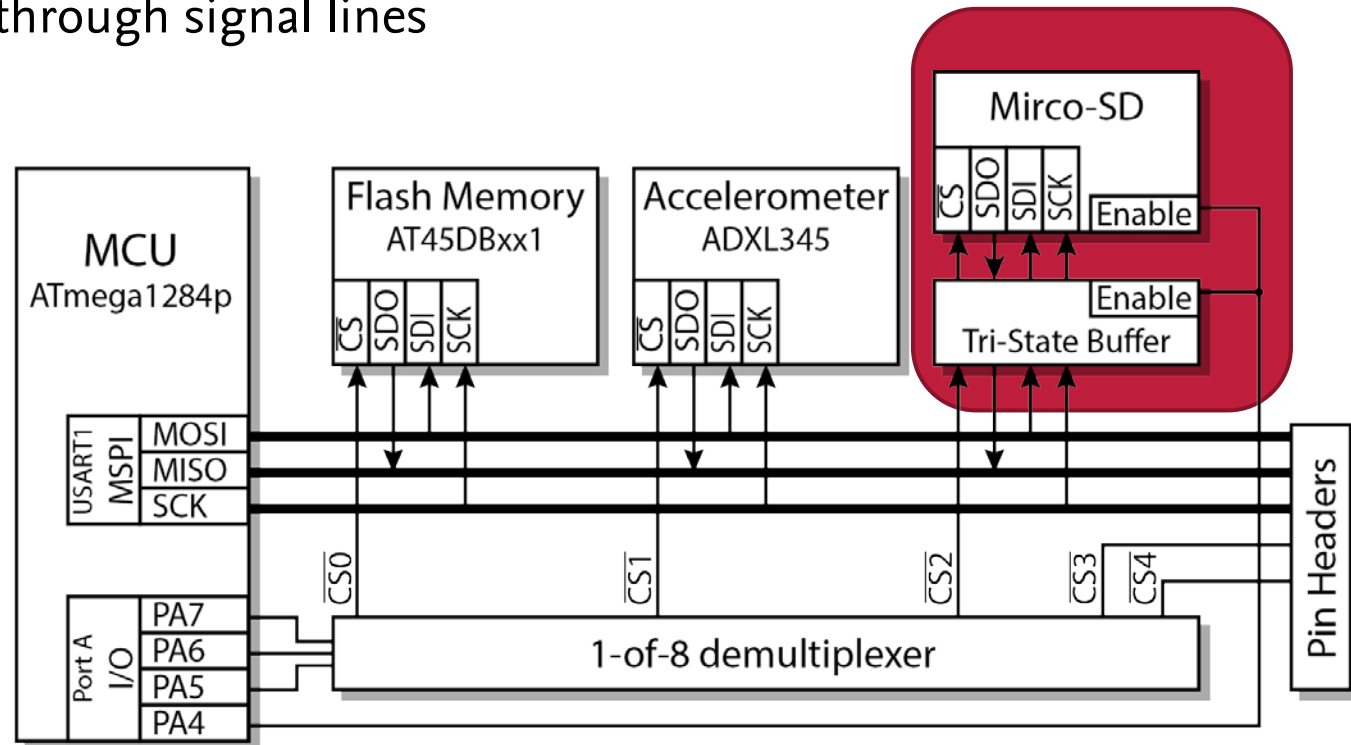




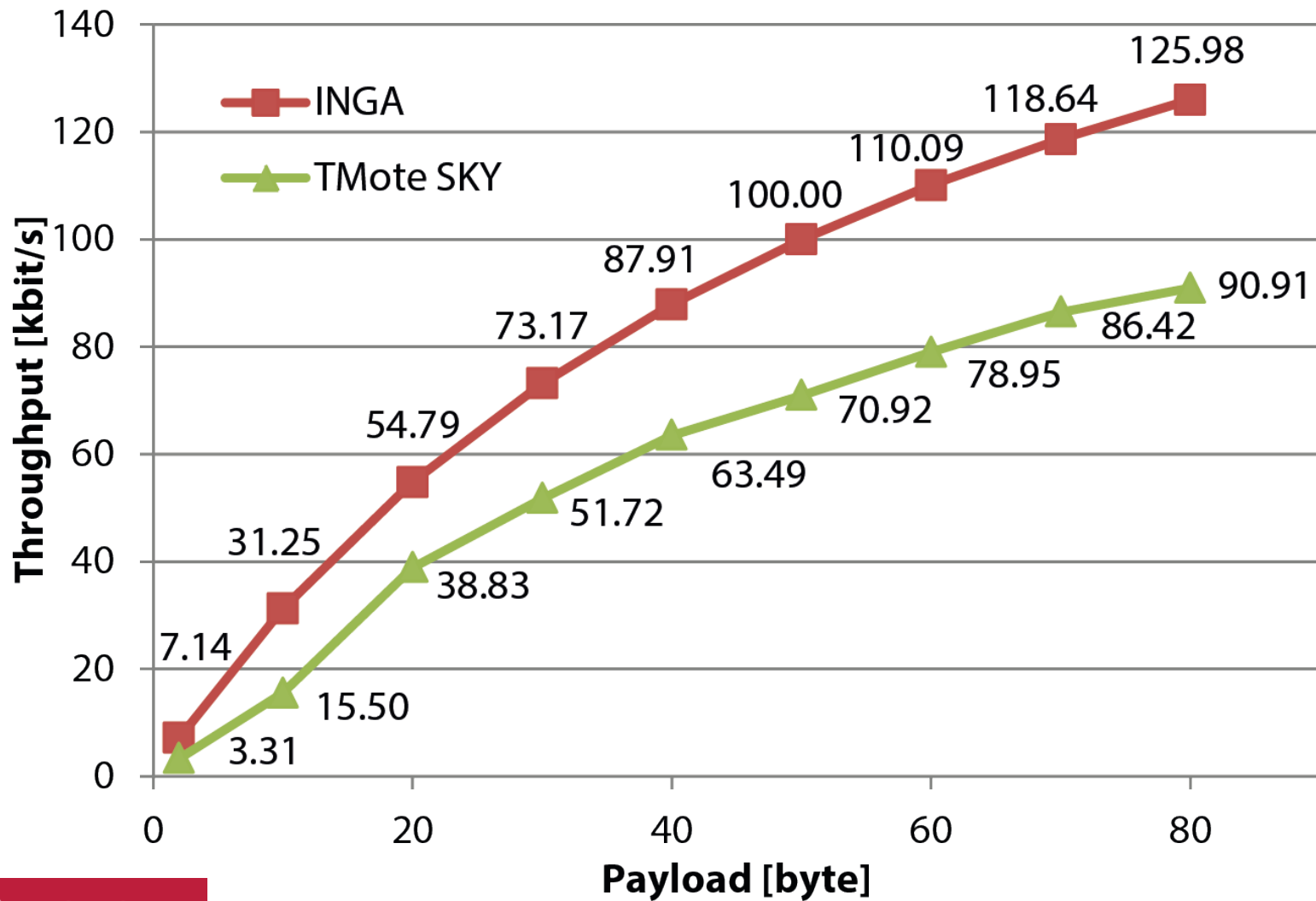
# (M)SPI-Bus: Micro-SD Card

## 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

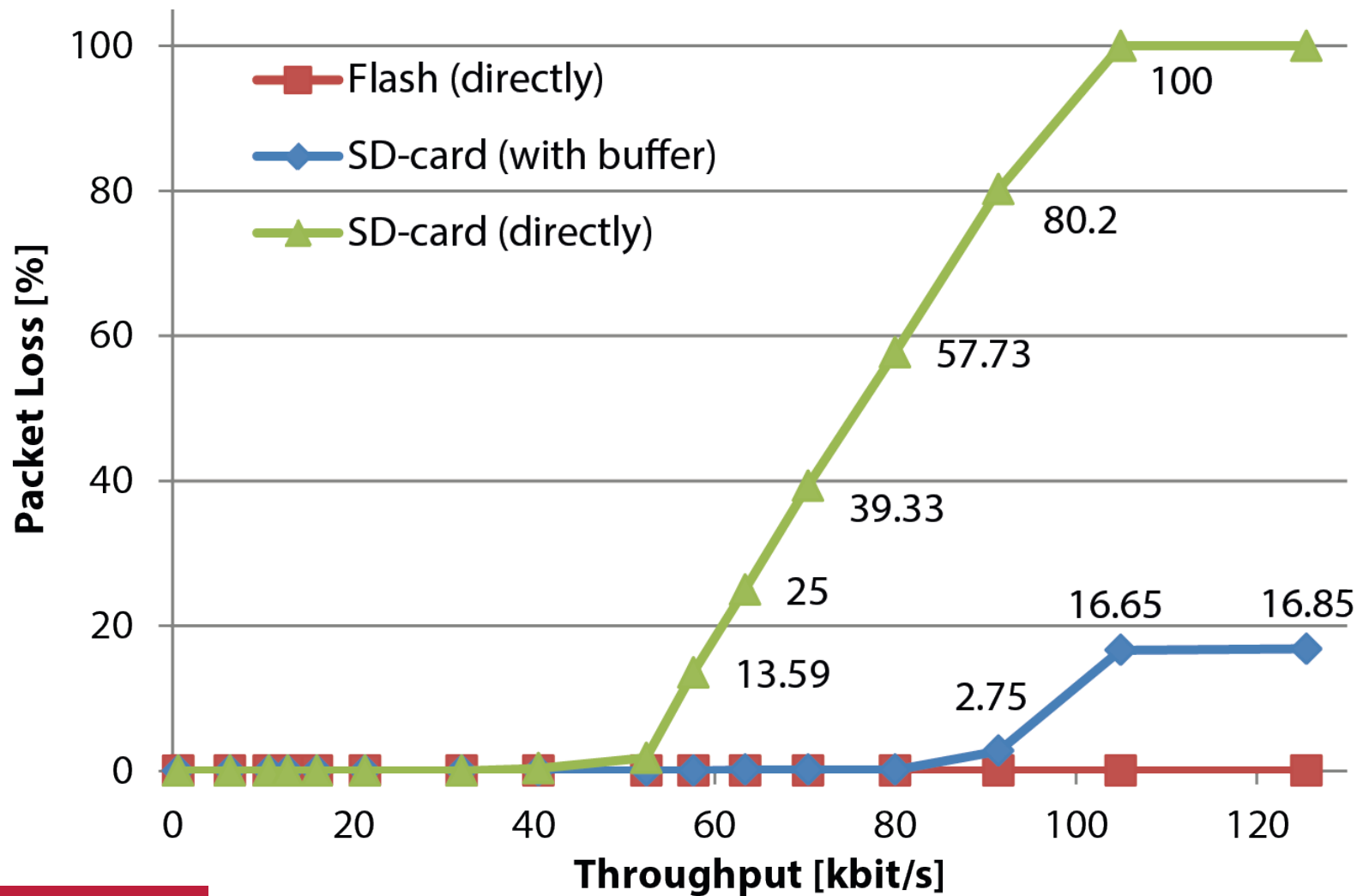


# Exemplary Evaluation: INGA vs. TMote Sky – Power Consumption

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

	<b>INGA</b>	<b>TMote Sky</b>
<b><math>I_{cc}</math></b>	<b>18.69 mA</b>	<b>19.69 mA</b>
<b>Max. transmit rate</b>	<b>125.98 Kbit/s</b>	<b>90.91 Kbit/s</b>
<b>Electric Charge</b>	<b>0.15 mAs per bit</b>	<b>0.22 mAs per bit</b>

# Exemplary Evaluation: Memory Access





# Current State & Ongoing Work

150 INGA devices built

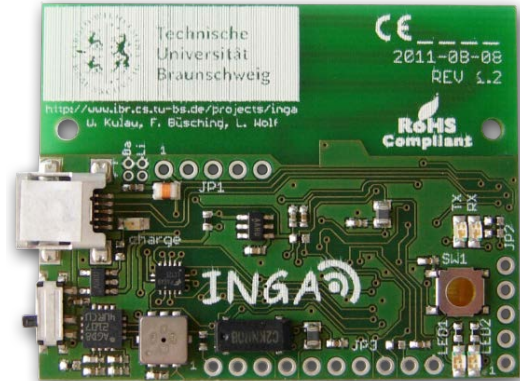
- Student lab – very interesting projects

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:

- <http://www.ibr.cs.tu-bs.de/projects/inga/>

Thanks for the attention!

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