Technische Universität Braunschweig

Institute of Operating Systems and Computer Networks

Leveraging RF-channel fluctuation for activity recognition

On active and passive systems; Continuous and RSSI-based signal features

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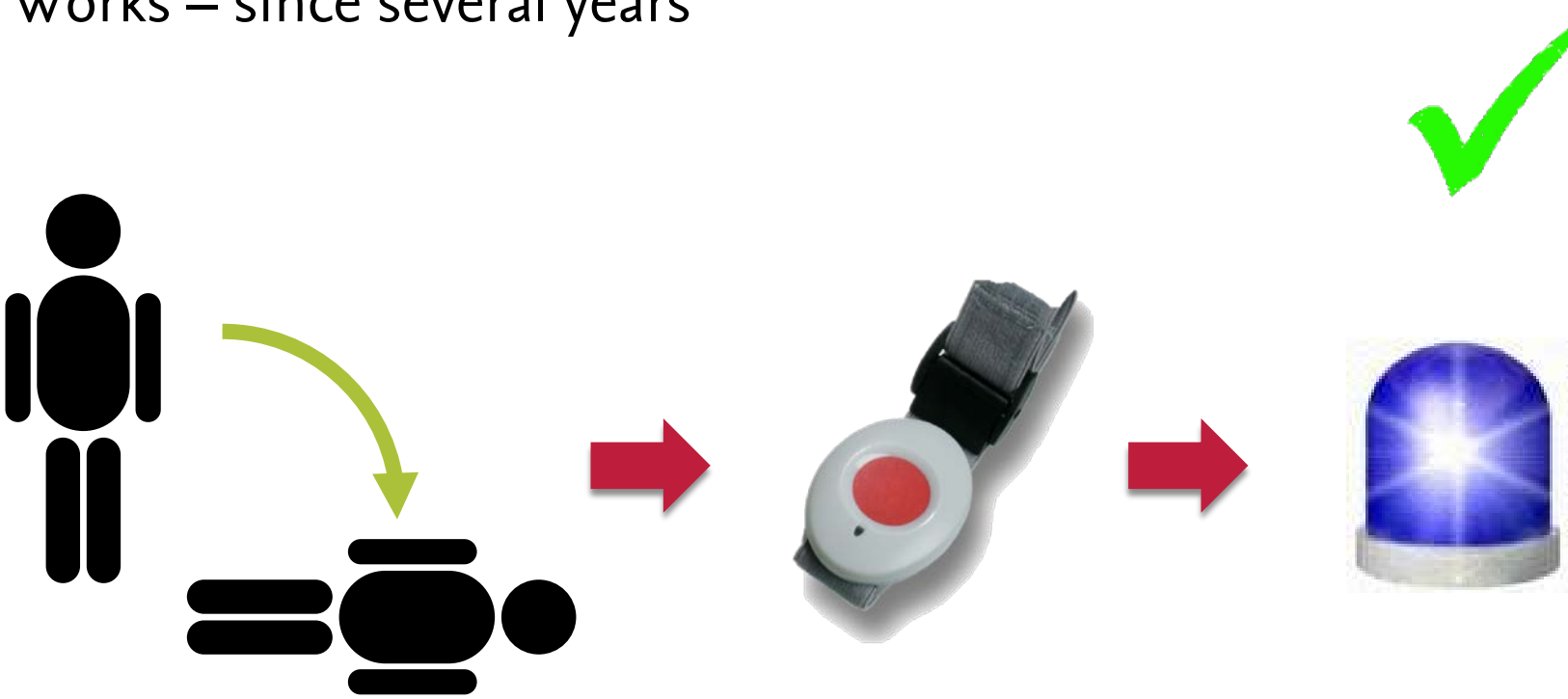
Outline

- Motivation: Why should anyone want to do this?
- Test Setup
- Results
- Conclusion

Personal Emergency Response System (PERS)

Observed behavior 1: Normal usage

- Works – since several years



Fall occurs

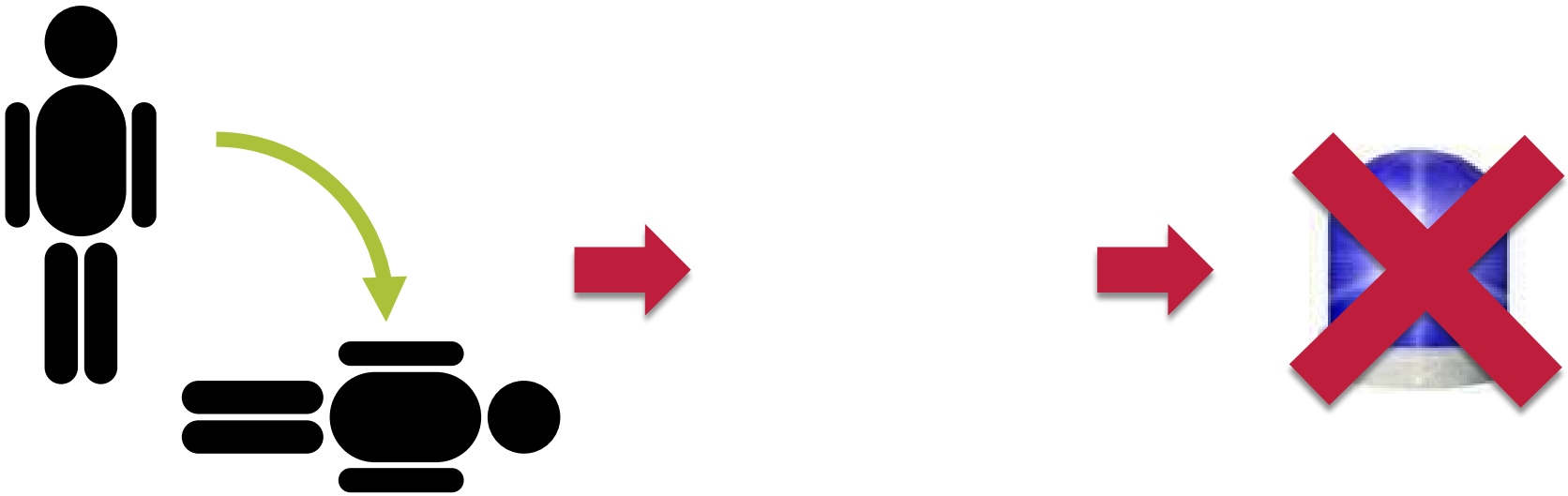
Button pressed

Alarm initiated

Personal Emergency Response System (PERS) – Non-Usage

Observed behavior 2: Non-usage

- Forgets to wear sender
- Doesn't even know where it is



Fall occurs

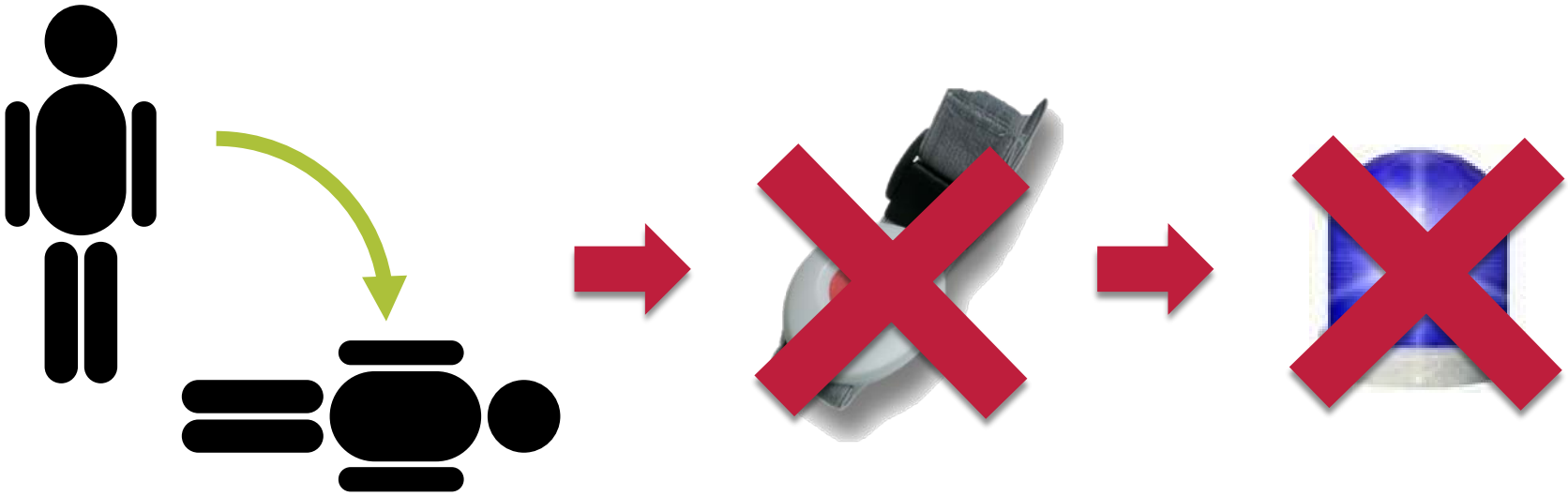
No button to press

No alarm

Personal Emergency Response System (PERS) – Refused Usage

Observed behavior 3: Refused usage

- "The mobile nursing service will come anyway – in 2-4 hours"
- "I'll wait here on the floor – don't want to bother anyone"



Fall occurs

Button not pressed

No alarm

Personal Emergency Response System (PERS) – Anxious Usage

Observed behavior 4: Anxious usage

- "I feel safe – I better wear that thing 24/7"
- Many false alarms during nighttime

Bad dream occurs

Button accidentally pressed

False Alarm

Summary: Personal Emergency Response System (PERS)

1. Normal usage
   - OK, this is boring… ✓
2. Non-usage
   - Additional stationary sensors for activity detection
3. Refused usage
   - Additional stationary sensors for activity detection
4. Anxious usage
   - Only stationary sensors for activity detection

→ Using RF-channel fluctuation for activity recognition may be a good idea!

Motivation for RF-based Activity Detection

- Worn devices are not always present when needed
- Most IoT-devices include a radio transceiver
- No interaction is required
- Not intrusive like cameras
- Higher acceptance

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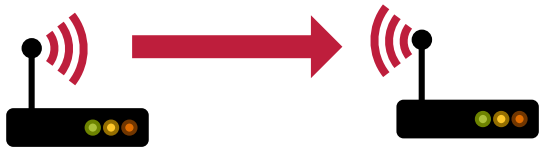
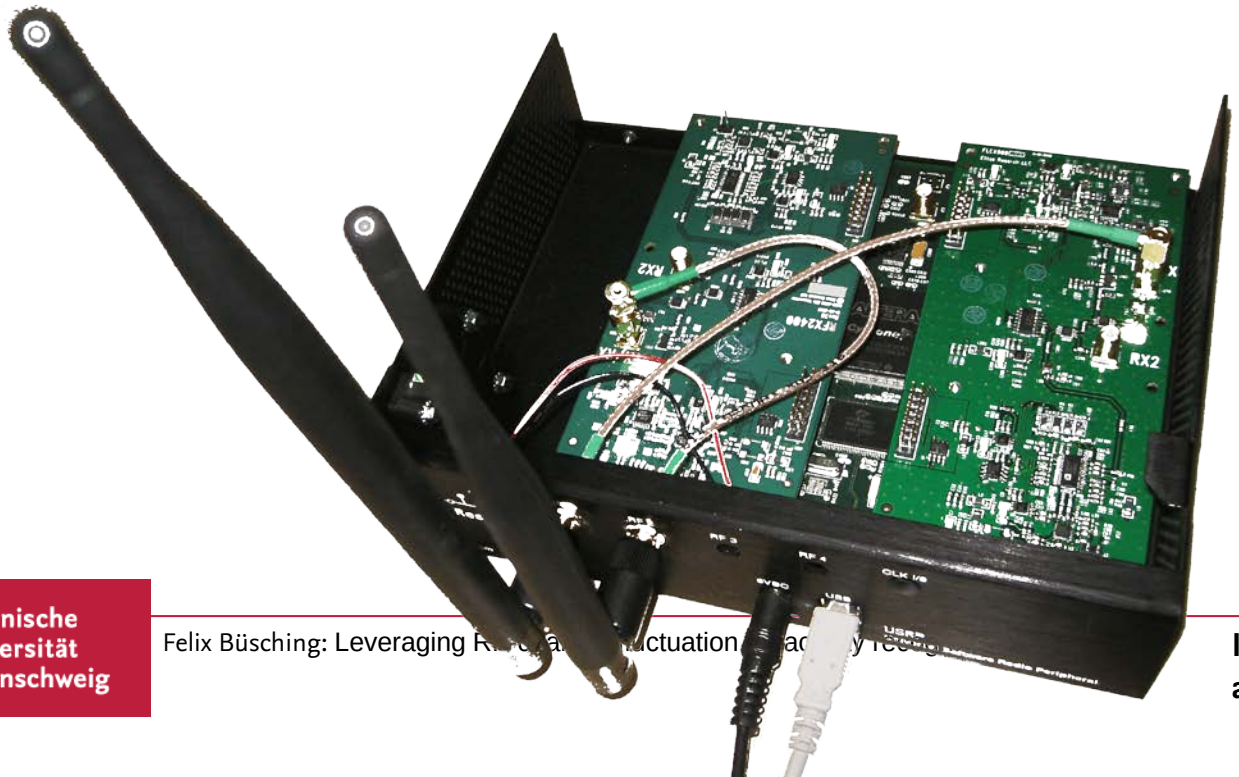
1/4 different devices

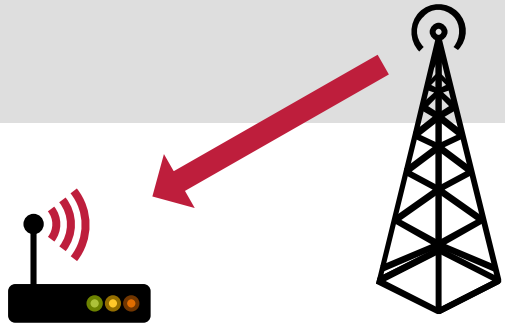
USRP1: Active SDR-based DFAR



- 900 MHz (RFX900 board)
- Vert900 Antenna
- Sine signal, continuously modulated on carrier
- 80 Hz sample rate



2/4 different devices



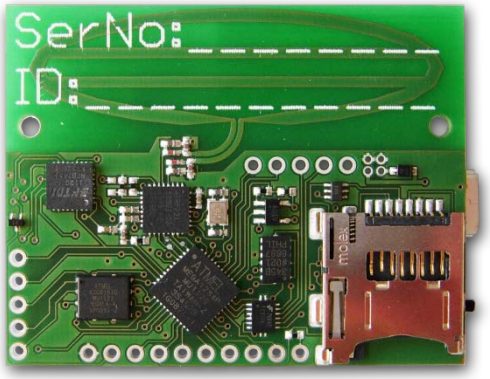
USPR N210: Passive SDR-based DFAR

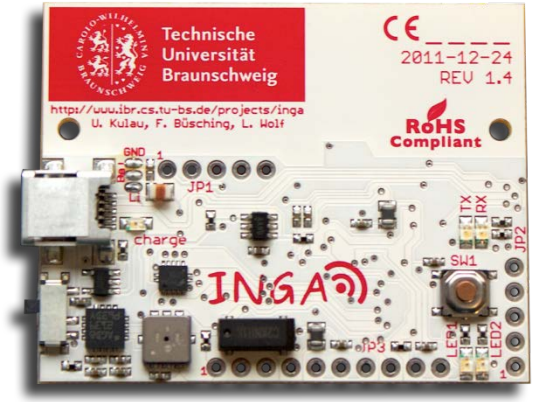
- 82.5 MHz (WBX board),
- Vert900 Antenna
- Environmental FM radio from nearby radio station
- 64 Hz sample rate

3/4 different devices

INGA WSN-Node: Active RSSI-based DFAR

- 2.4 GHz IEEE802.15.4 radio
- PCB-Antenna
- UDP-Packets
- 100 packets per second
- RSSI-values from radio (received MAC-Frames)

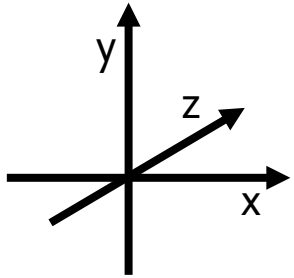




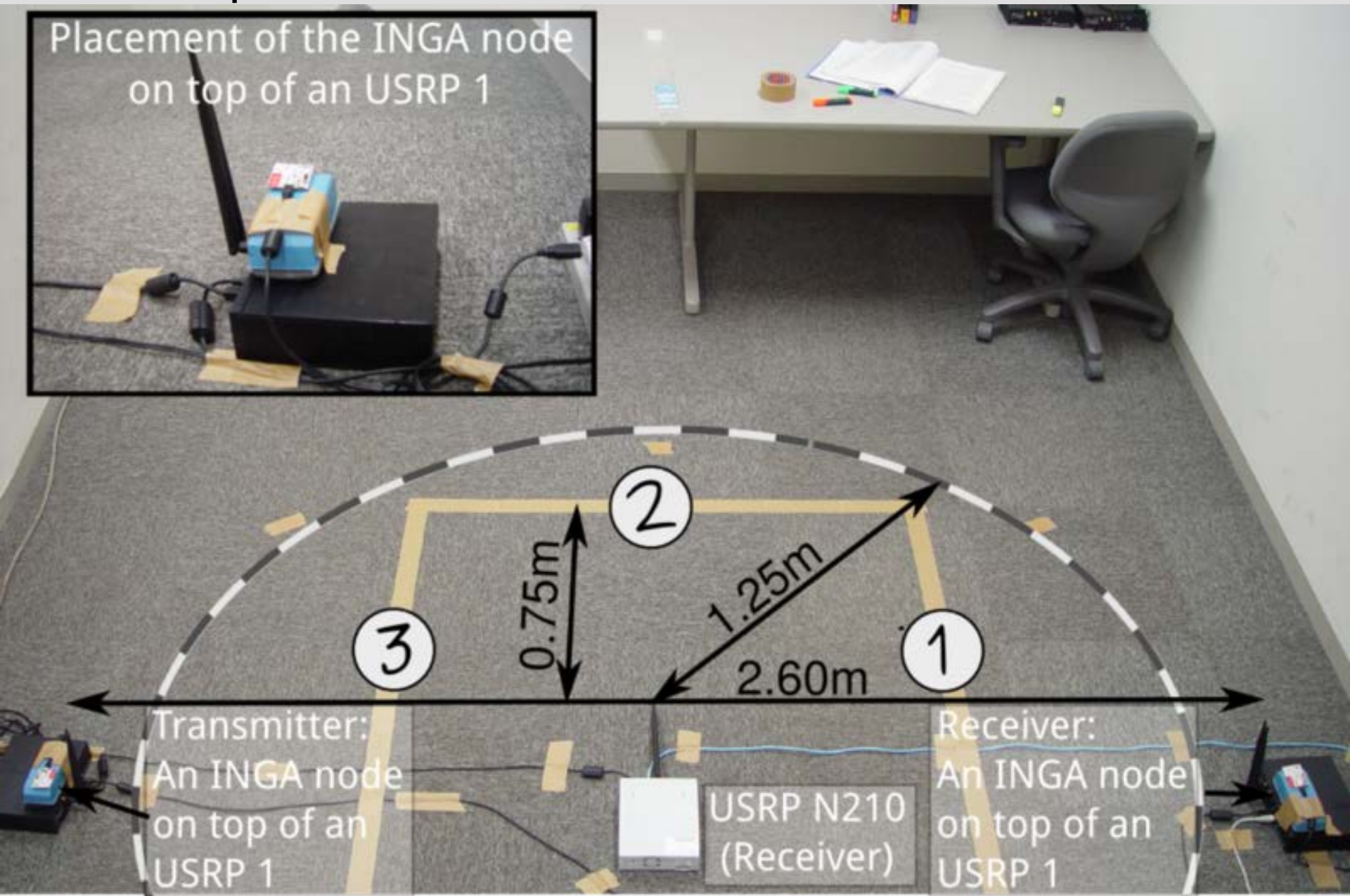
4/4 different devices

Iphone 4: Accelerometer-based activity recognition

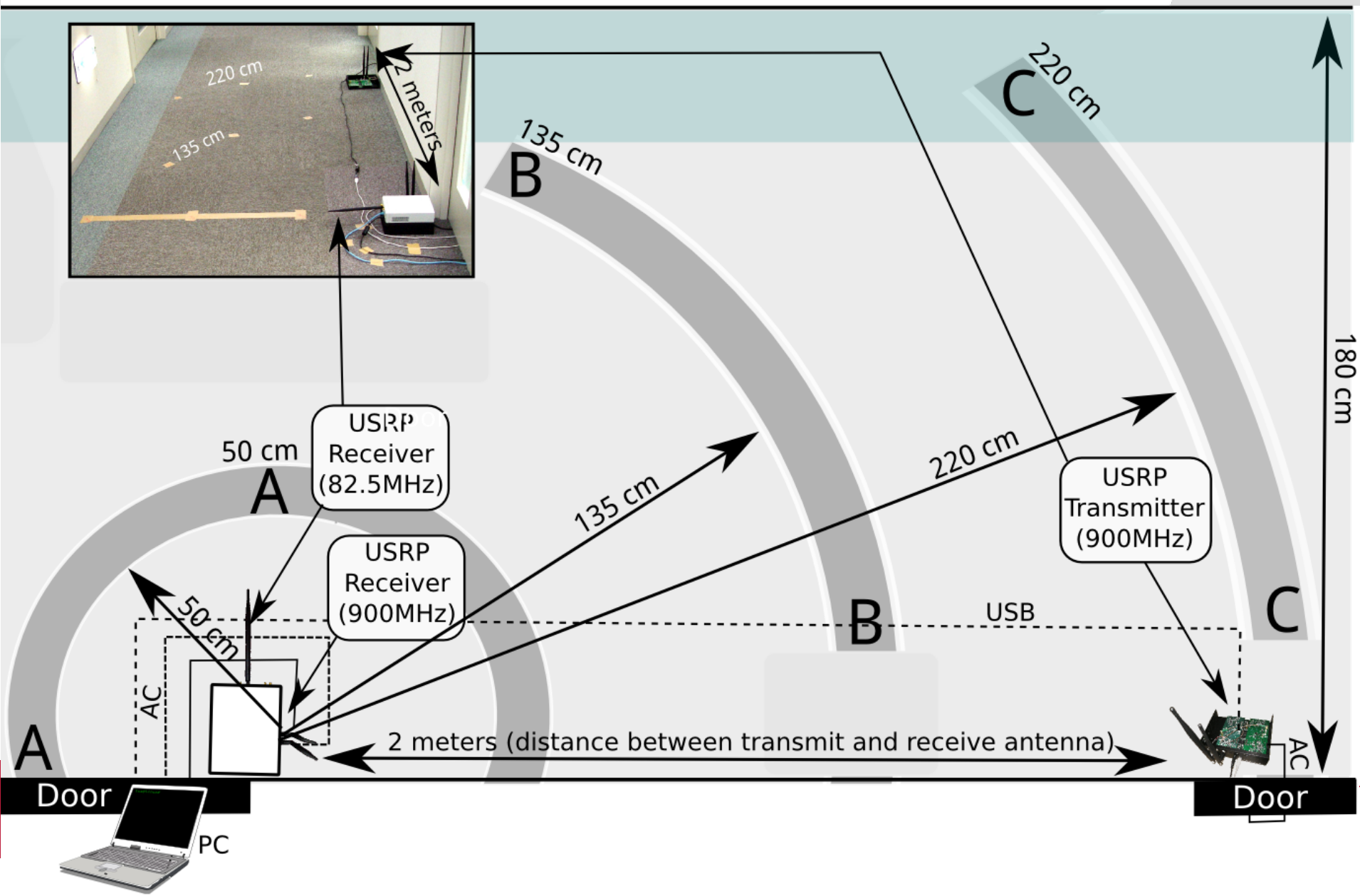
- 3 axis accelerometer
- Attached to body
- 40 Hz sampling rate
- Recorded simultaneously to other experiments



Test Setup: Scenario 1



Test Setup: Scenario 2



Performed Activities

Empty room

Standing

- At 3 different locations

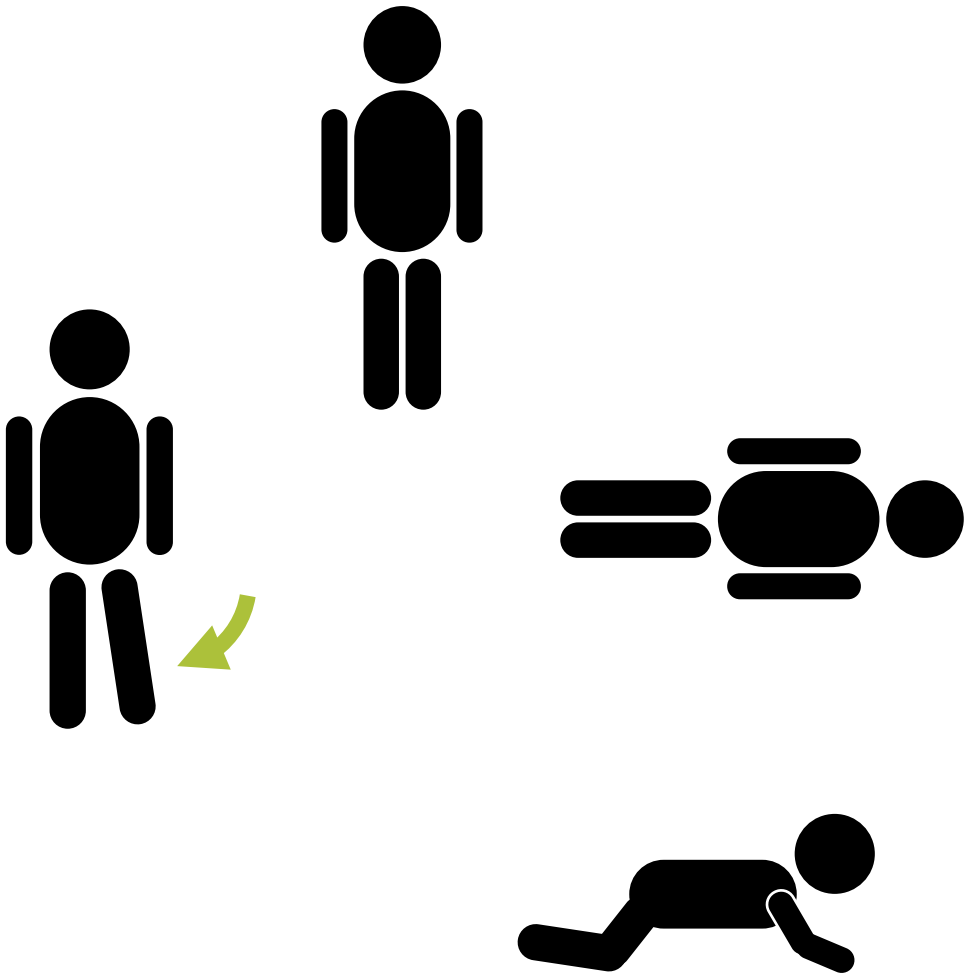
Lying

- At 3 different locations

Walking

- At 3 different speeds

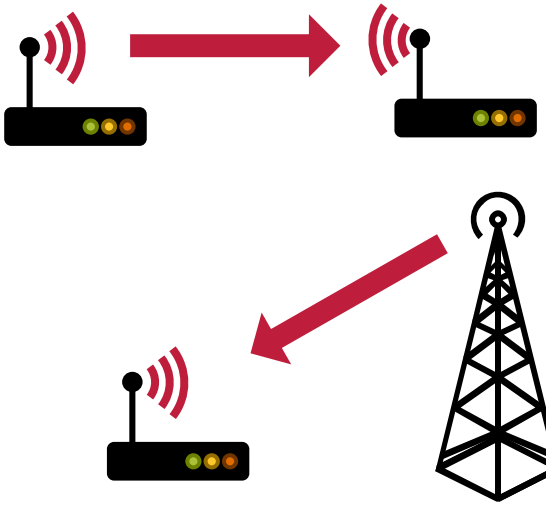
Crawling



Summary: Different Approaches and Scenarios

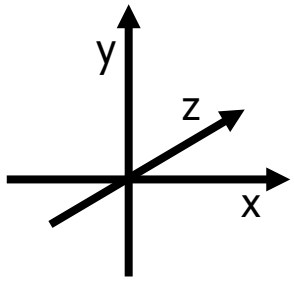
Approaches

- Active SDR-based DFAR
- Passive SDR-based DFAR
- Active RSSI-based DFAR
- Accelerometer-based activity recognition



2 Scenarios

- Room
  - All four approaches evaluated
- Hallway
  - No WSN evaluation



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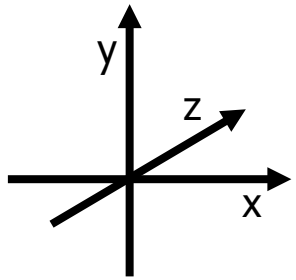
Confusion Matrices – Classification Accuracy – k-NN algorithm 1/2

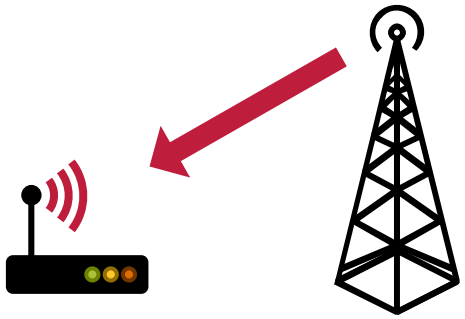
Accelerometer-based activity recognition

	Lying	Standing	Walking	Crawling
Lying	**.976**	.024		
Standing		**1.0**		
Walking			**.955**	.045
Crawling			.253	**.748**



Passive SDR-based DFAR

	Lying	Standing	Walking	Crawling
Lying	**1.0**			
Standing	.056	**.980**	.022	
Walking	.023		**.874**	.102
Crawling	0.44		.144	**.811**



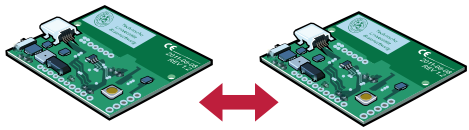
Confusion Matrices – Classification Accuracy – k-NN algorithm 2/2

Active SDR-based DFAR

	Lying	Standing	Walking	Crawling
Lying	.904	.096		
Standing	.096	.898	.006	
Walking		.013	.962	.025
Crawling		.038	.212	.750

Active RSSI-based DFAR

	Lying	Standing	Walking	Crawling
Lying	.882	.118		
Standing	.120	.869	.007	.004
Walking			.953	.047
Crawling		.010	.439	.551



Summary, Conclusion & Outlook

Thanks for the attention!
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Device-free, no worn sensors, no interaction required

Monitoring of elderly by RF-Channel Activity Recognition

- works!
- … nearly as good as accelerometer based
- (Passive is not that good)

Monitoring smart spaces works for simple activities.

Outlook

- Only RSSI-based information will be needed for activity detection