Aalto University
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Radio-based Device-free activity recognition and implicit ad-hoc usable security

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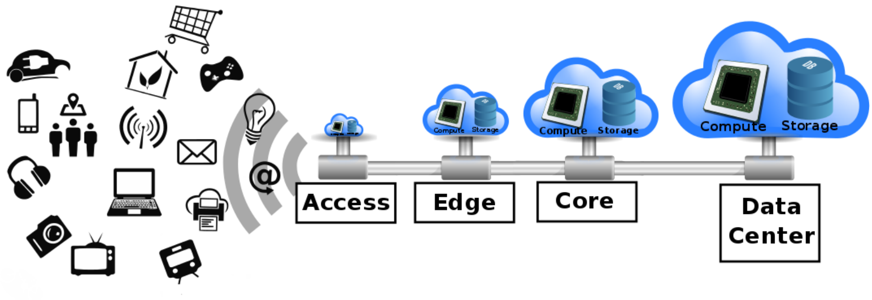
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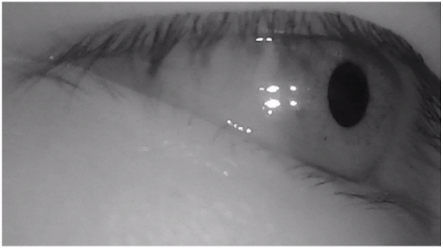
Edge
Core
Data Center

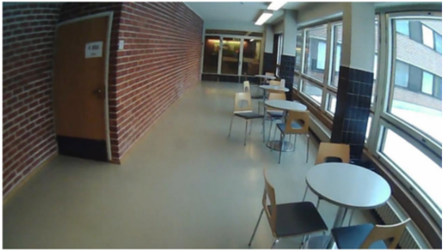
Secure authentication from an Egocentric Camera

Secure authentication from Egocentric camera



b)

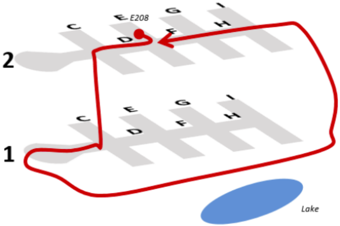
a)



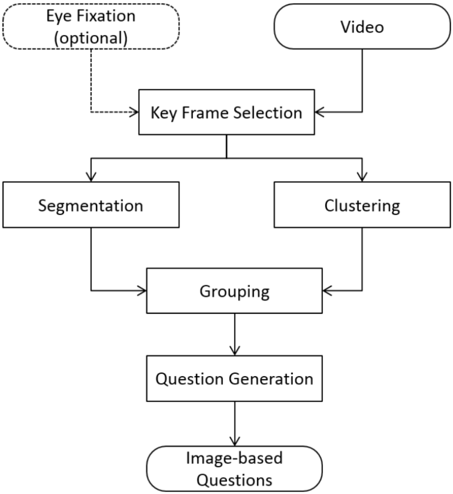
c)

Try and break it:

http://ambientintelligence.aalto.fi/passframe/



Frame selection and challenge generation



	Key Frames	Processing Time
Tablet-class (AMD E2-1800 1.7GHz)	118	51 sec
Desktop (Intel Core I5-2400 3.1GHz)	118	9 sec

Segmentation

Figure 3. Images selected by eye fixations (bottom) and frame sampling (top)

clustering

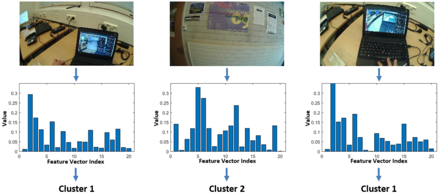
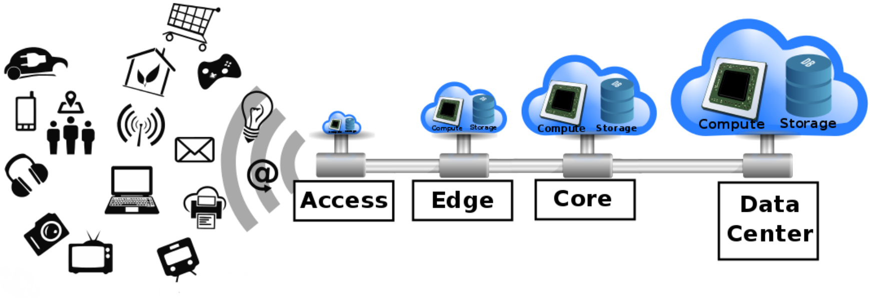


Figure 6. Feature values extracted from video frames (We only show absolute values of a part of feature vectors for better visualization)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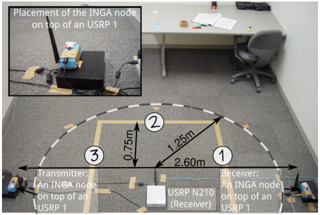
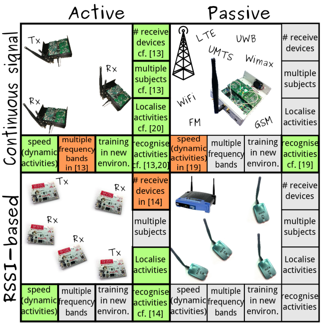
RF-based device-free activity recognition

RF-based device-free activity recognition





Active SDR-based DFAR (USRP1)
Frequency: 900MHz (RFX900 board), Vert900 Antenna, 4dBi antenna gain
Signal: Sine signal, continuously modulated onto the carrier
Sample rate: 80 Hz

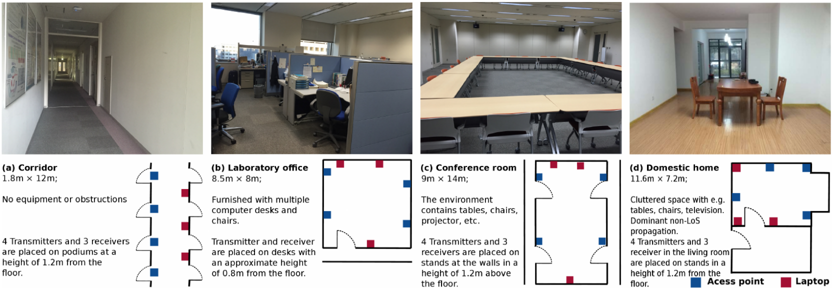
Passive SDR-based DFAR (USRP N210)
Frequency: 82.5MHz (WBX board), Vert900 Antenna, 4dBi antenna gain
Signal: Environmental FM radio captured from a nearby radio station
Sample rate: 64Hz

Active RSSI-based DFAR (INGA wsn nodes, v1.4)
Frequency: 2.4GHz IEEE802.15.4, PCB High Gain-Antenna
Signal: RSSI samples from packets transmitted between nodes
Sample rate: Transmission of 100 packets per second

Accelerometer-based activity recognition (Iphone 4)
Signal: 3-axis accelerometer
Sample rate: 40 Hz

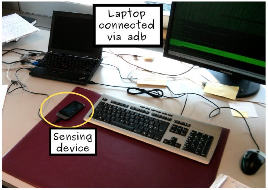
Walking Standing Crawling
Lying empty

Modelling CSI vectors via multivariate Gaussian

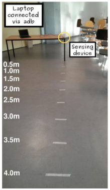


We model the amplitude of every CSI reading at location 'y' to approximately follow a multivariate Gaussian Distribution. Location is then predicted via the maximum likelihood estimate.

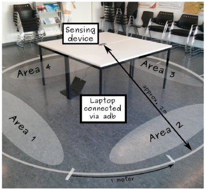
Situation and gestures from passive RSSI-DFAR



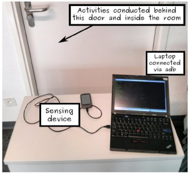
(a) Office environment at ETH



(b) Lecture room at TU-BS

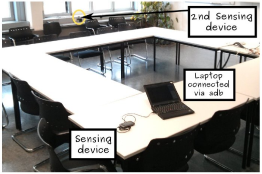


(c) Scenario for the distinction of walking speed

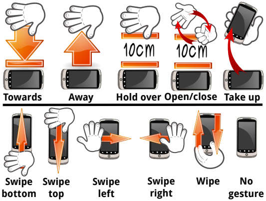


(d) Activities conducted behind a closed door

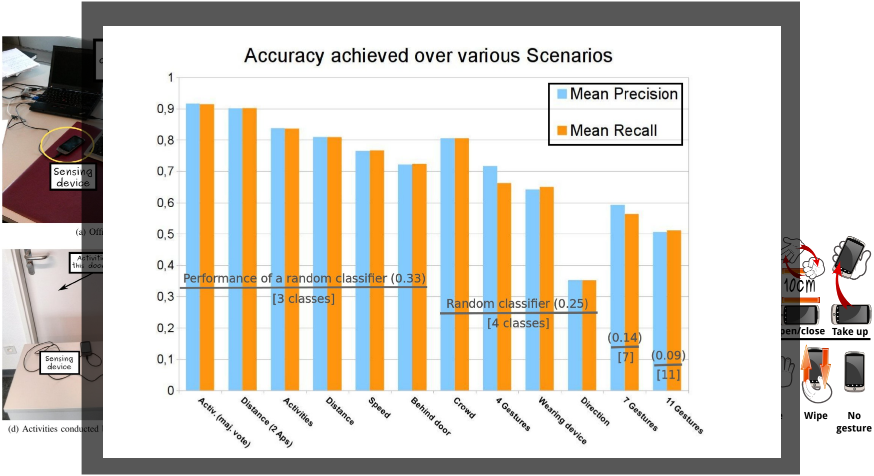
(e) Sensing device inside pocket



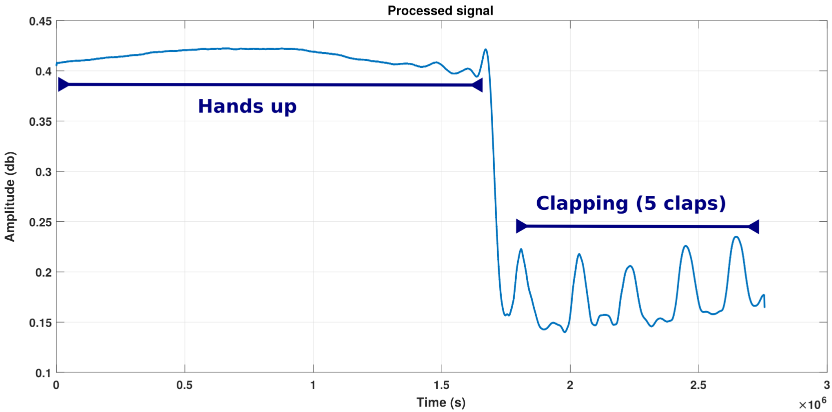
(f) Meeting room at ETH

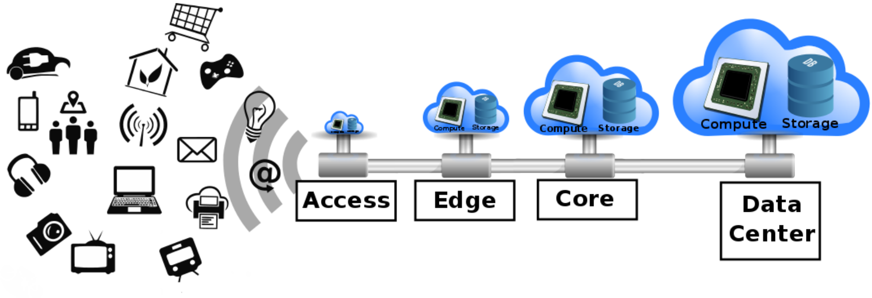


Situation and gestures from passive RSSI-DFAR



Gesture recognition from RF

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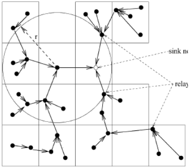
Calculation during transmission on the channel

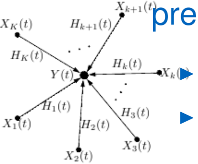
Motivation: Computation during transmission[a]



- Max. rate to compute & communicate functions
- Mention: Collisions might contain information

[a] Giridhar et al, Toward a theory of in-network computation in wireless sensor networks, IEEE Comm. Mag., vol. 44, no 4, pp. 98-107, april 2006

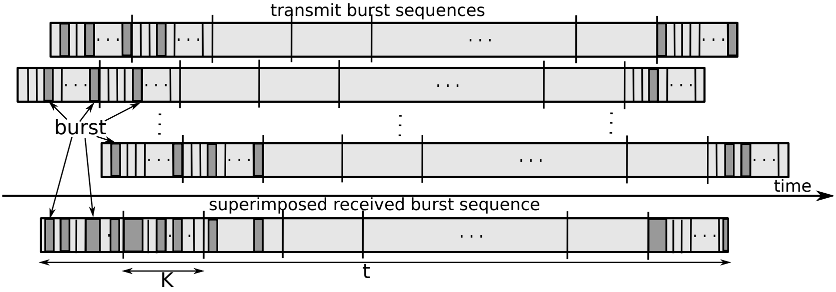
Calculation of by means of post- and pre-processing[a]



- Requires accurate channel state information
- Requires identical absolute transmit power

[a] M. Goldenbaum, S. Stanczak, and M. Kaliszan, On function computation via wireless sensor multiple-access channels, IEEE Wireless Communications and Networking Conf., 2009

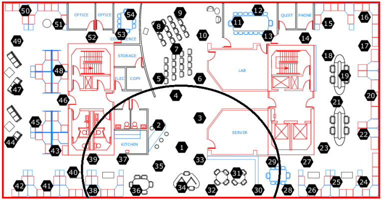
Calculation during transmission on the channel
Utilising Poisson-distributed burst-sequences

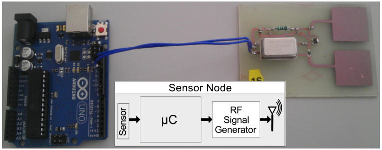


- Addition, subtraction, division and multiplication at the time of wireless data transmission via Poisson-distributed burst-sequences
- Adding Poisson processes *i* with mean μ_i will result in a Poisson process with mean $\sum_{i=1}^{n} \mu_i$.

Calculation during transmission on the channel

Case study to compare the calculation accuracy

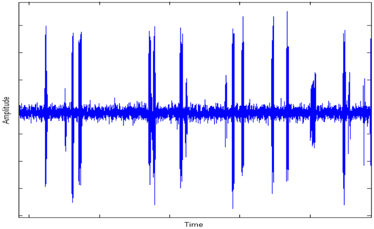


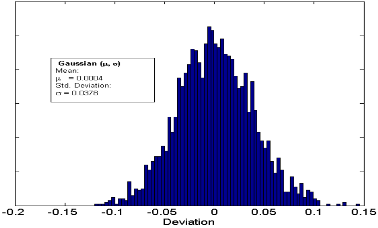


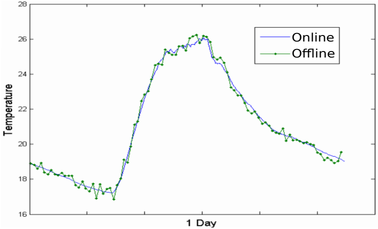
- Utilise data from the Intel Berkeley laboratory network (here: temperature)[1]
- Transmission of data by simple sensor nodes

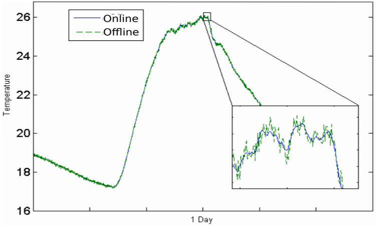
[1] http://db.csail.mit.edu/labdata/labdata.html

Calculation during transmission on the channel









Thank you!

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