OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG

Design and Implementation of an Intelligent and Model-based Intrusion Detection System for IoT Networks

Laboratory for IT-Security and Compliance
Faculty of Computer Science and Mathematics
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FAST-CSP

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Agenda

- About the Speaker
- Motivation
- Architecture of the iIDS
- Data Insights of Network Traffic
- Snorkel
- AI-based Network Data Analysis
- Conclusion and Future Work

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About the Speaker

- September 2018 – July 2021
  Business Informatics B.Sc.
  University of Applied Sciences Regensburg

- Since September 2021
  Master of Applied Research (M.Sc.)
  - IoT, IT-Security & Compliance, AI
  University of Applied Sciences Regensburg

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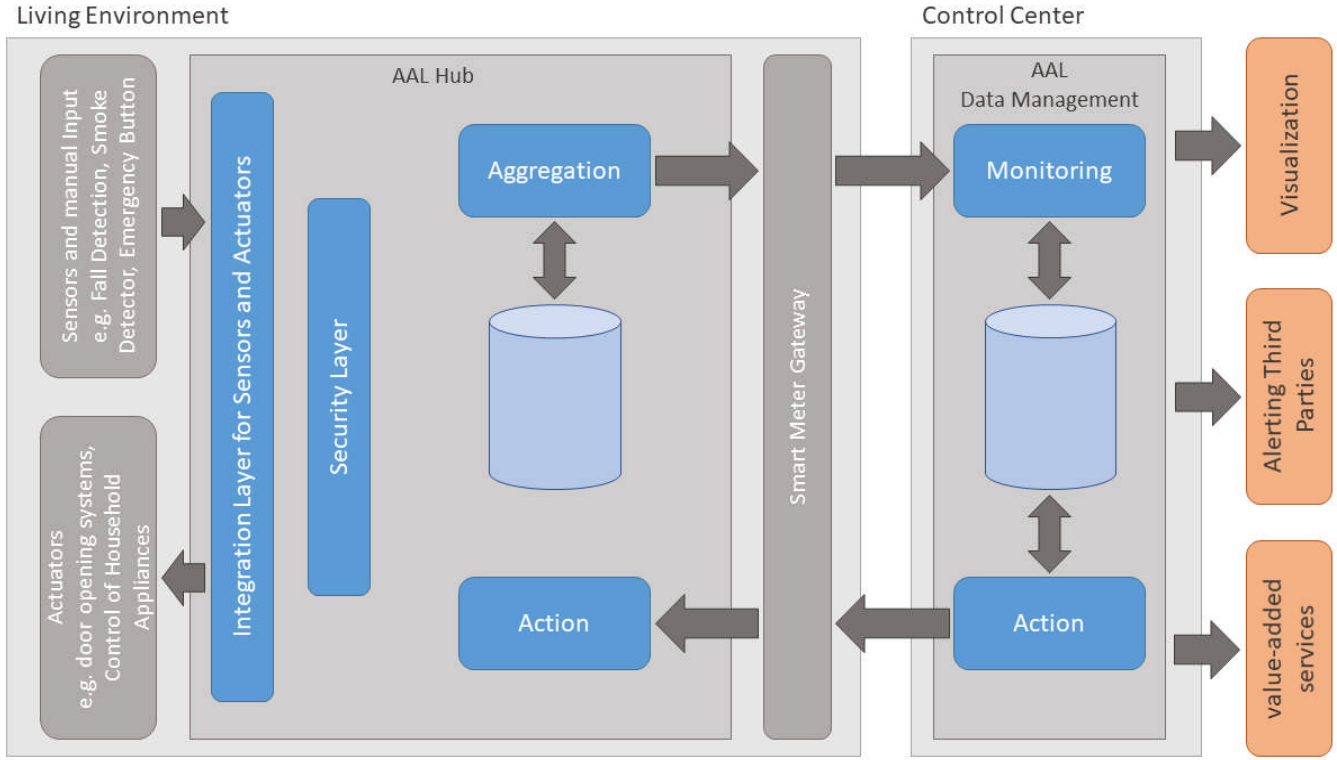
Previous Work

Architecture of an intelligent Intrusion Detection System for Smart Home

Julian Graf, Katrin Neubauer, Sebastian Fischer, Rudolf Hackenberg
IEEE International Conference on Pervasive Computing and Communications Workshops
23-27 March 2020

Secure Gateway for Ambient Assisted Living (SEGAL)



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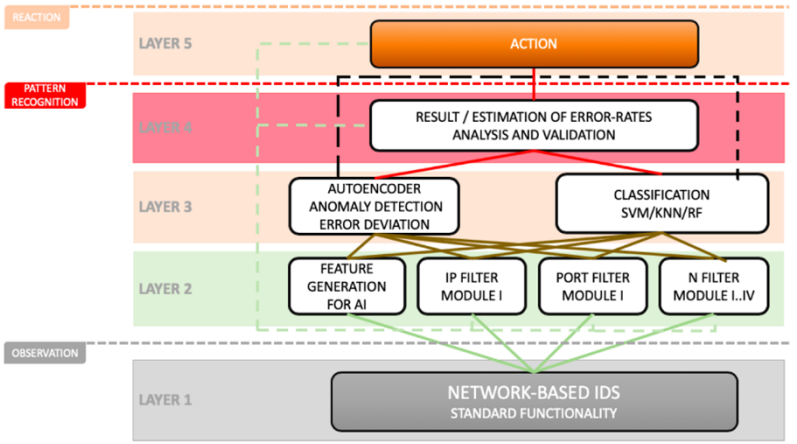
Architecture of the iIDS

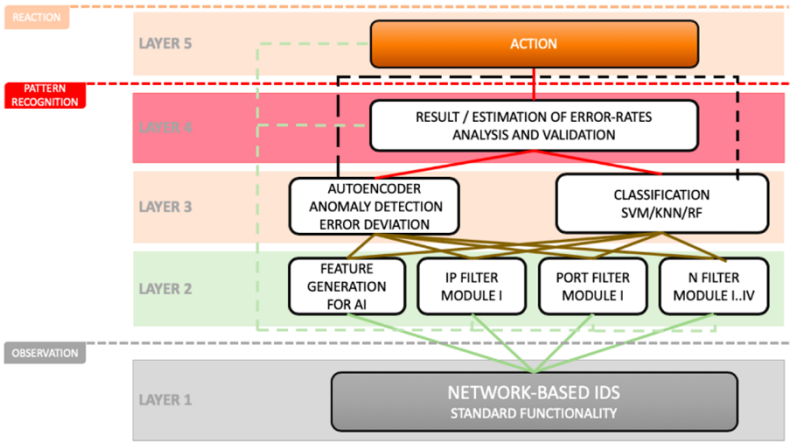
- **Layer 1**
  Packet capturing of WLAN and Bluetooth data with Libpcap / Pcap4J
- **Layer 2**
  Rule-based modules to analyze port and address information and data preparation for the upcoming AI modules
- **Layer 3**
  AI-based modules for anomaly detection and intrusion classification



Architecture of the iIDS

- Layer 4
  Analysis of the return values from the rule-based and AI-based modules to calculate the probability of an intrusion

- Layer 5
  Deployment of countermeasures to prevent or limit damage to the system



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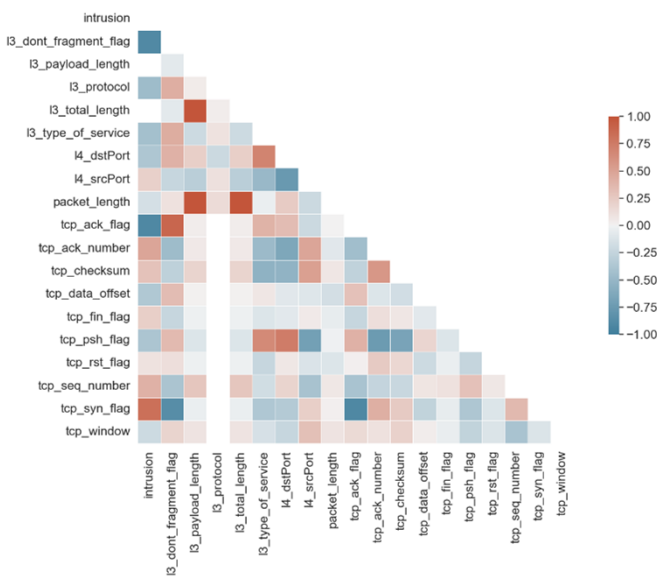
Data Insights

- 52 different header information are collected from the protocols of Layers 2, 3 and 4 of the ISO/OSI model.

- Most important features
  - TCP flags (e.g. Synchronization, Acknowledgment, Reset)
  - Port information (Source and Destination port number)
  - Packet and Payload lengths
  - Type of service (e.g. ICMP packets with a service type 8 for an Echo request)



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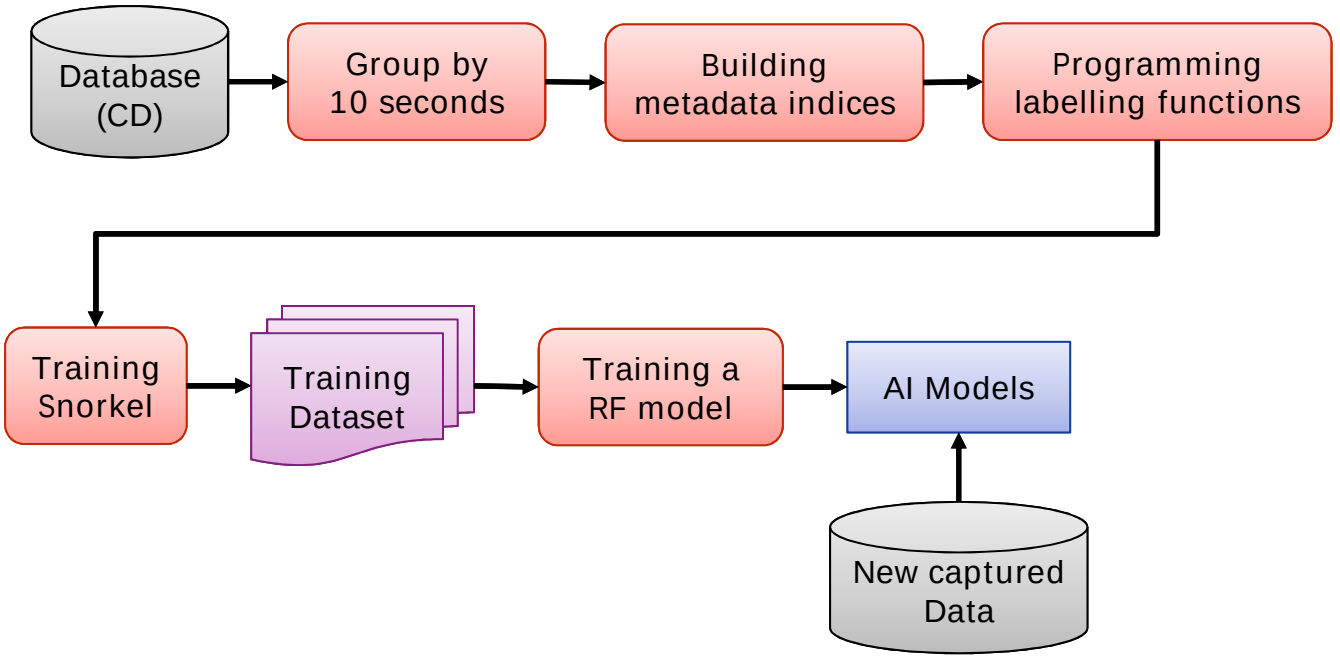
Snorkel

- Developed by Alex Ratner and colleges at the Stanford University since 2015
- Creates training data sets for other AI models
- Based on Tensorboard/Tensorflow 1.5
- Deprecated since late 2020

snorkel

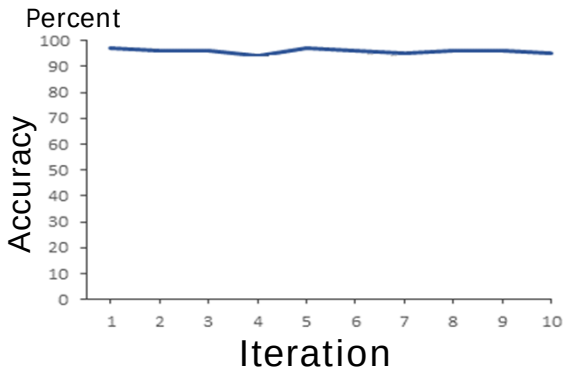
https://www.snorkel.org/

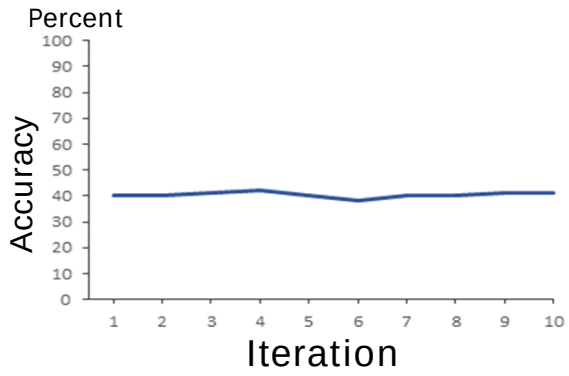
Approach Overview



Labeling Functions

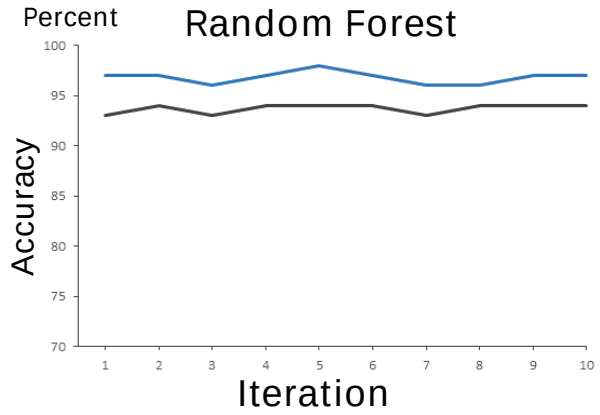
- For each category a separate labelling function is necessary
- Labelling functions have a large influence on the time performance

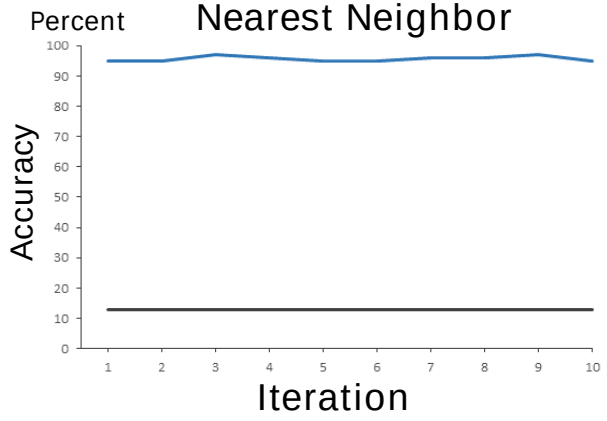




AI Model Training Results

- Snorkel data set is used to train the AI models
- The test of the trained AI models is done with ungrouped captured data
- 5 different AI models are tested
  - Nearest Neighbor
  - Support Vector Machine
  - Logistic Regression
  - Decision Tree
  - Random Forest
- Best Result: Random Forest





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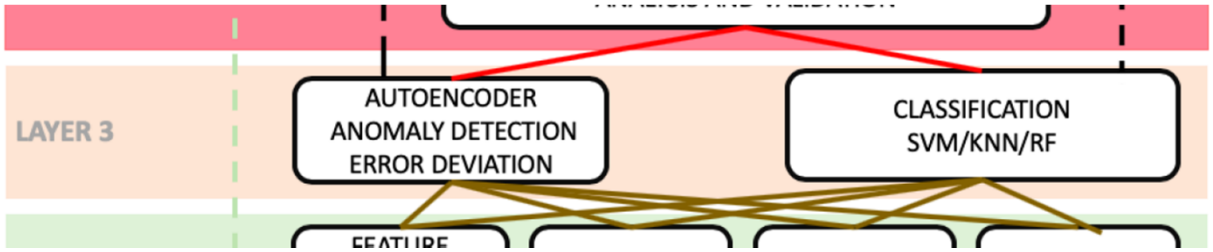
iIDS – Machine Learning Models



Anomaly Detection

Neuronal Network:
- AutoEncoder Algorithm

Binary Search Tree:
- Isolation Forest Algorithm

Attack Classification

Neuronal Network:
- CNN – VGG-19

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Future Work

- Development of the 4th Layer – Calculation of the probability of an intrusion
- Generate new normal and attack data for training and testing of the AI-based modules
- Testing of the overall system with the additional data