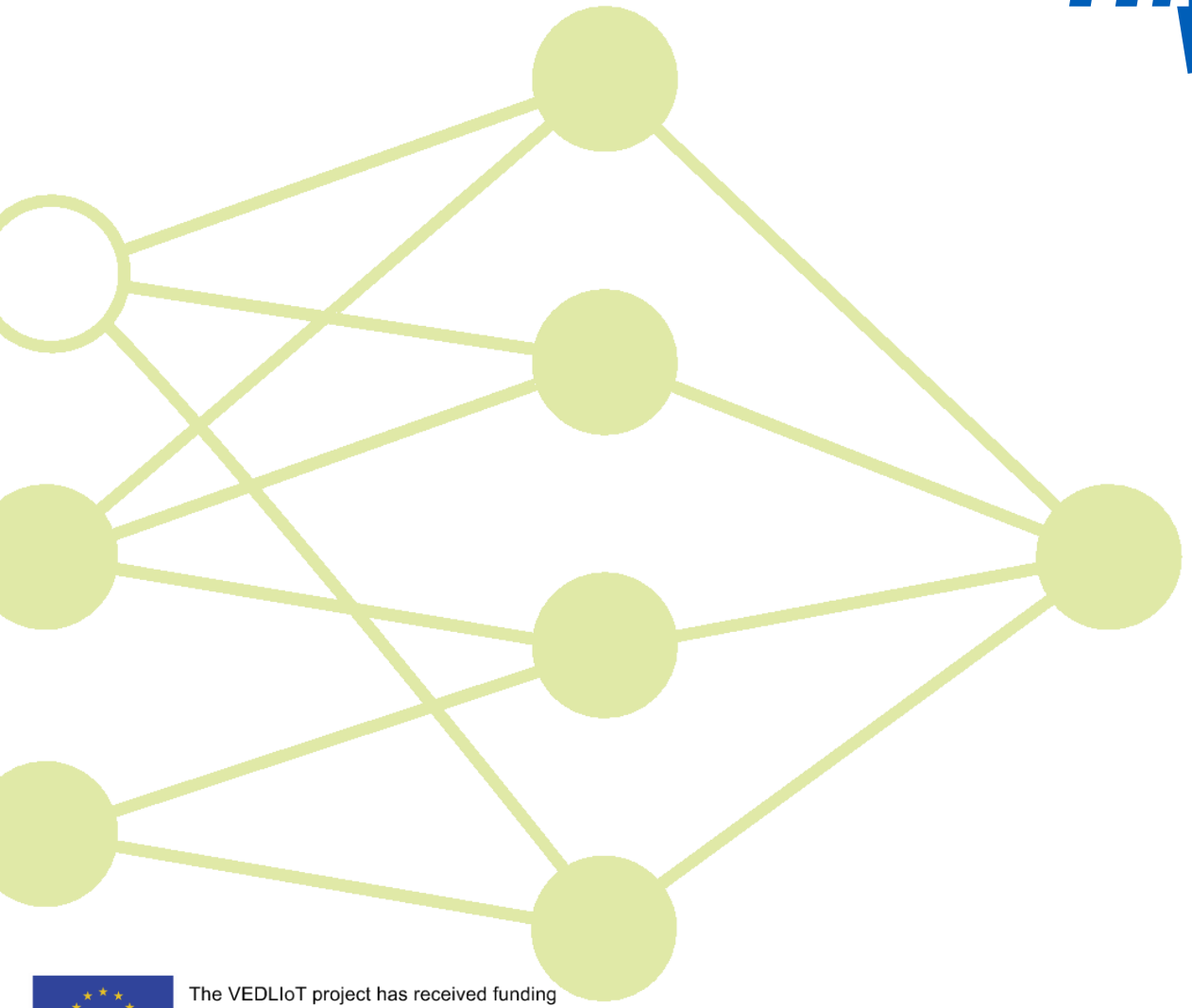


Next-generation IoT insights

VEDLIoT project overview and results

Jens Hagemeyer
Bielefeld University

The VEDLIoT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957197

Big Picture

VEDLIoT
Very Efficient Deep Learning in IoT

Requirements

Smart Home

Industrial IoT

Automotive AI

Security & Safety

Modelling & Verification

Applications

Middleware

Toolchain

embedl

Emulation

RENODE

Benchmarking & Deployment

Kenning

Trusted Execution & Communication

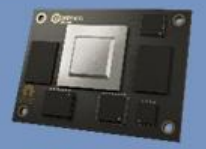
Microserver & Accelerators

Xilinx
Kria

Coral SoM

COM-HPC
Xilinx Zynq
UltraScale+

Jetson AGX
NVIDIA Xavier



RPi CM4
ARVSOM

SMARC
Xilinx Zynq
UltraScale+

Monitoring

Safety & Robustness

Hardware Platforms

Embedded/
Far Edge

u.RECS

Near Edge

t.RECS

Cloud

RECS|Box

RISC-V extensions

VEDLIoT Hardware Platform

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	Far Edge Computing	Near Edge Computing	Cloud Computing	
CPU	SMARC 2.1 Intel Atom 	COM-HPC Server Size D Intel Xeon D 	COM Express ARM v8 Server SoC Hi1616 	COM Express AMD EPYC 3451 
GPU SoC	 Jetson nano NVIDIA Orin NX	 COM-HPC Size B NVIDIA Orin AGX	 Jetson TX2 NVIDIA Tegra X2	
FPGA SoC	SMARC Xilinx Zynq UltraScale+ 	COM-HPC client Xilinx Zynq UltraScale+ 	 COM Express Intel Stratix 10 	COM Express Xilinx Zynq 7045
ML SoC	 M.2 PCIe Hailo-8	 M.2 PCIe Hailo-8	 Grayskull Tenstorrent	

u.RECS

t.RECS

RECS|Box
Durin

RECS|Box
Deneb

# Sites	>100K	>10K	100-10K	<100
Footprint	Custom	Compact (1RU)	Medium (2RU)	Large (3RU)
Power Budget	<30 W	< 500 W	500 W – 2 KW	> 2 KW
# Microserver	max 2	up to 3	up to 48	up to 144

Full co-design:
DL accelerator and model optimizations

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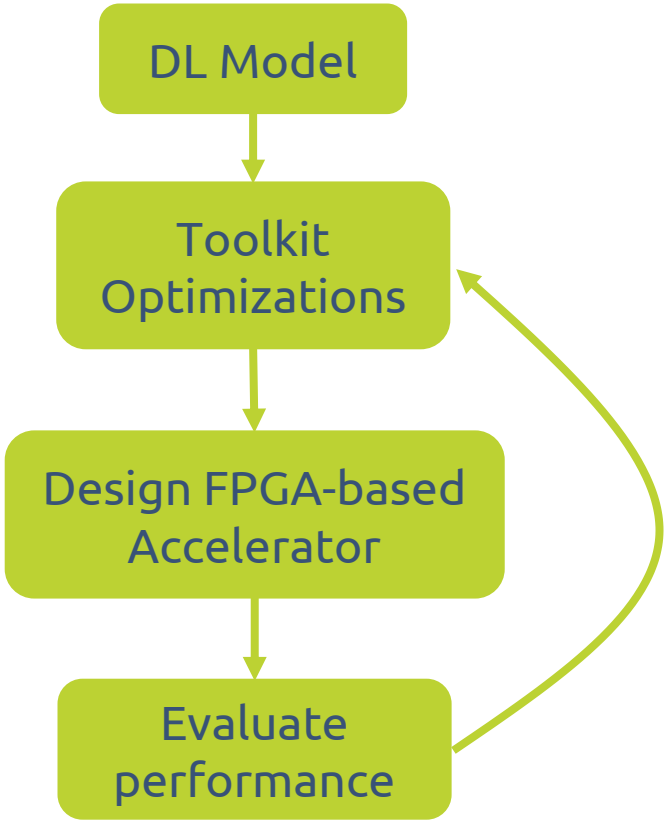
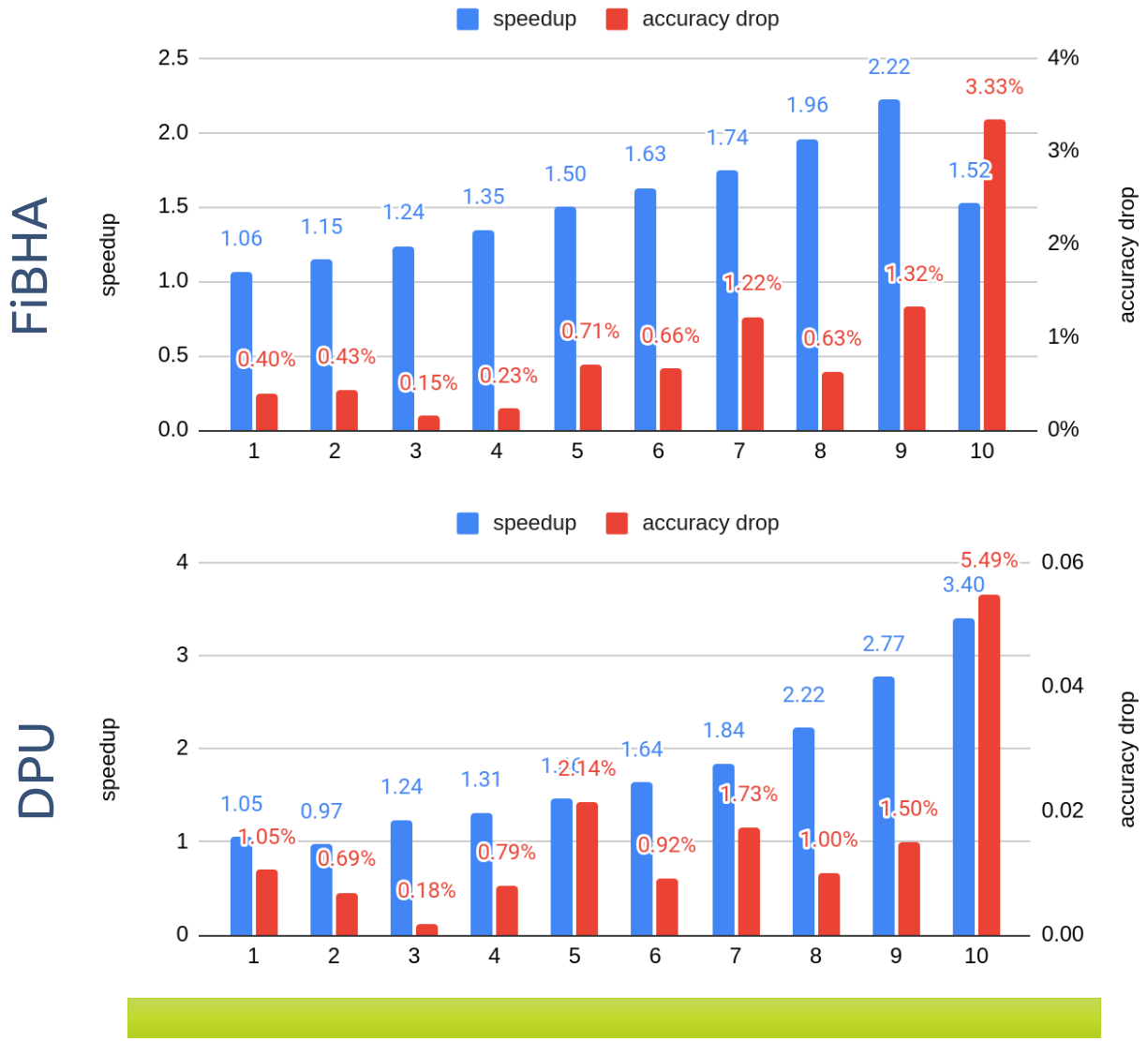
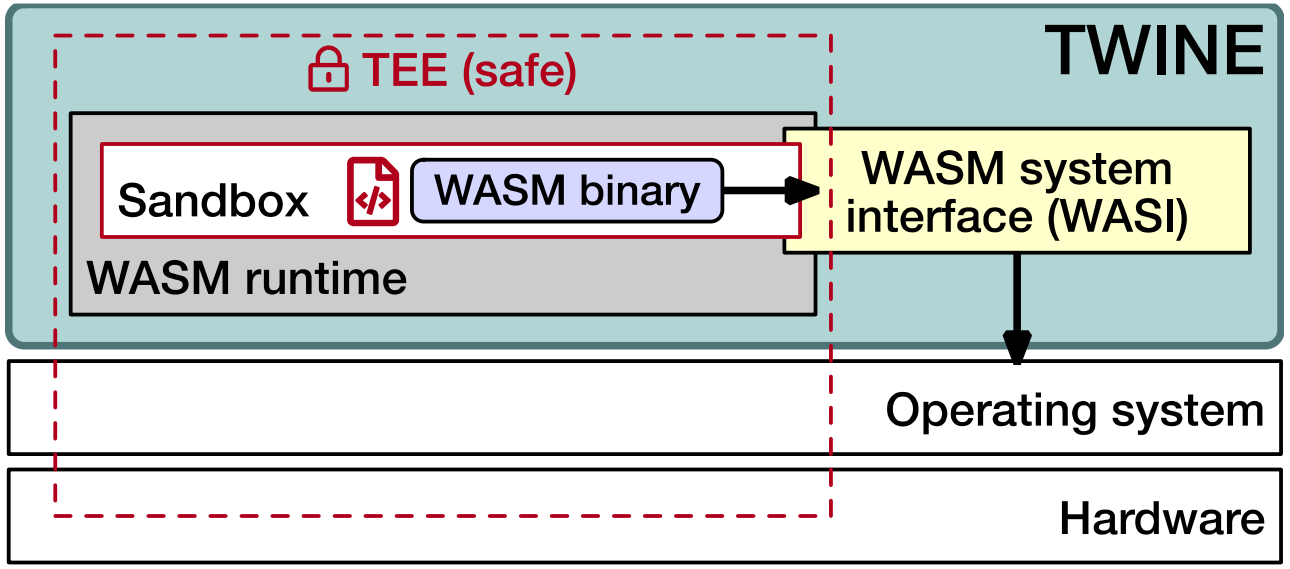




Security

- Common environment for running distributed applications
  - WebAssembly runtime + Trusted Execution Environment
  - Security for edge (and cloud) devices
- Advances on attestation
  - Better support for edge devices
  - Distributed (Byzantine fault-tolerant) attestation and configuration service



A compositional architecture framework for AIoT

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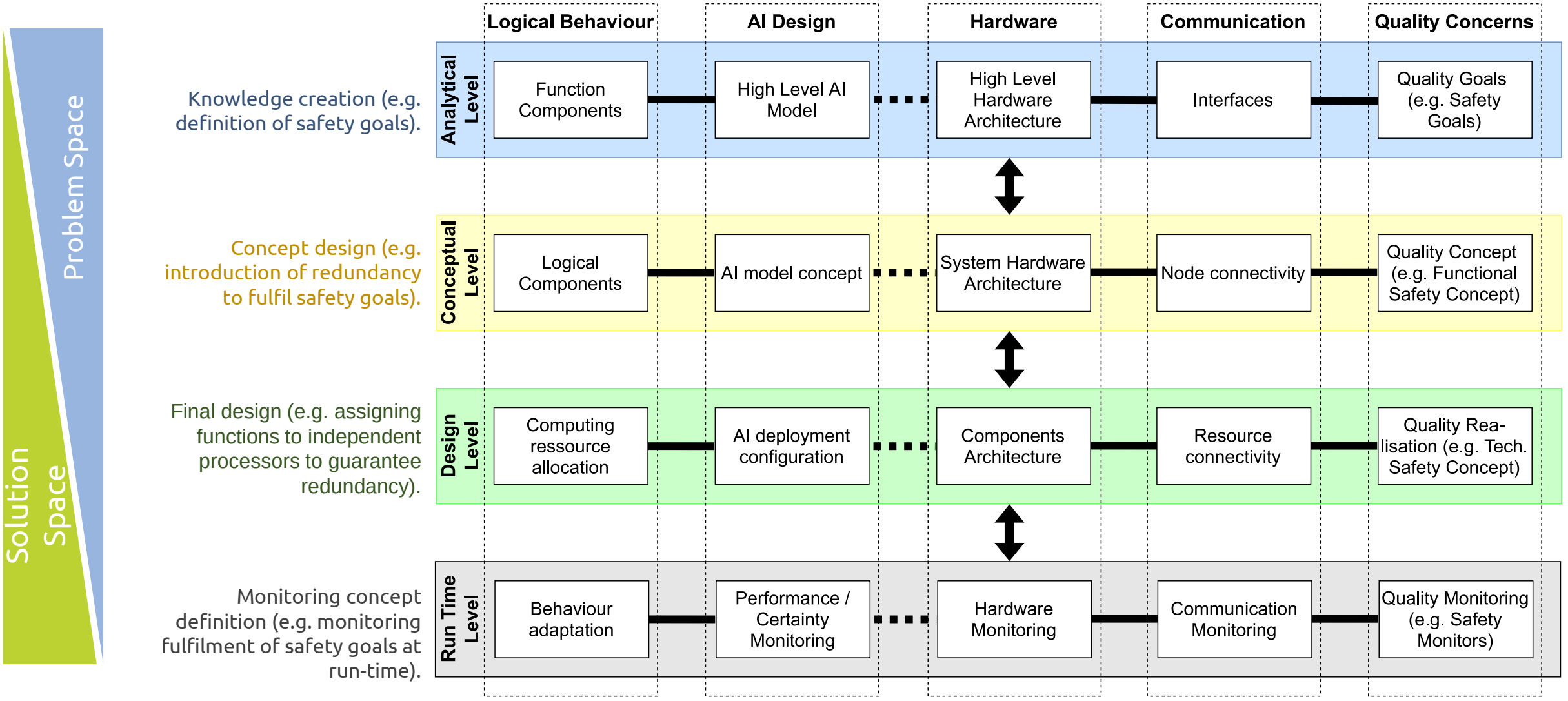
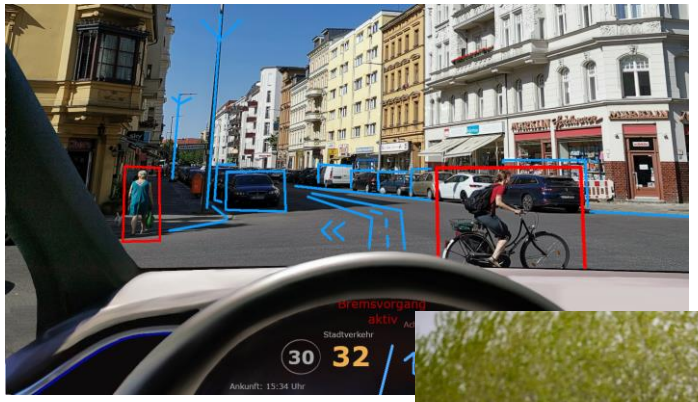
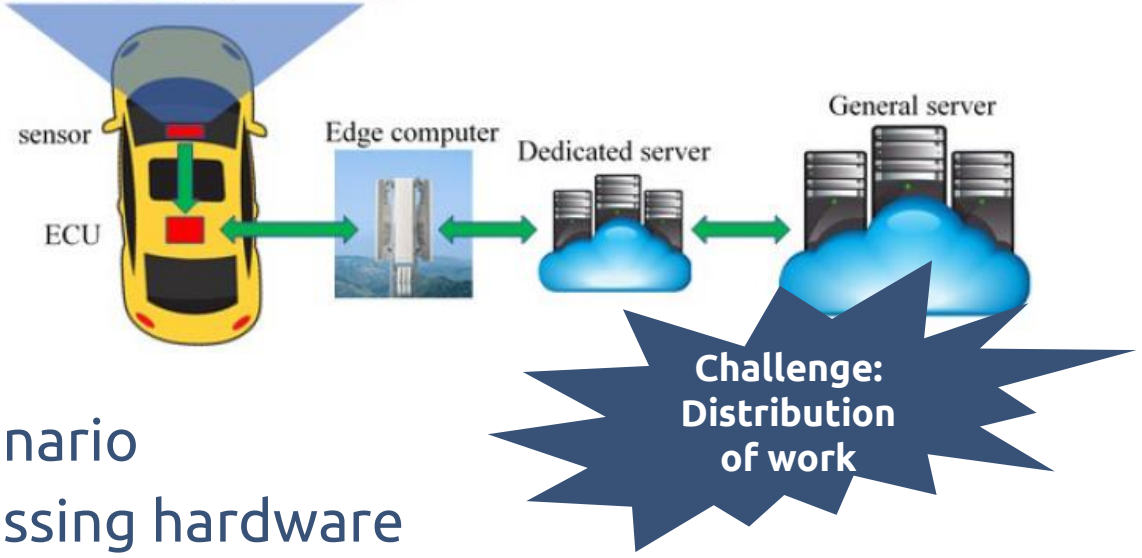
Very Efficient Deep Learning in IoT



Use case: Automotive





- Focus on collision detection/avoidance scenario
- Improve performance/cost ratio – AI processing hardware distributed over the entire chain

Demonstrated distribution across embedded, edge, cloud with at least 2x eff. improvement

Use case: Industrial IoT – drive condition classification

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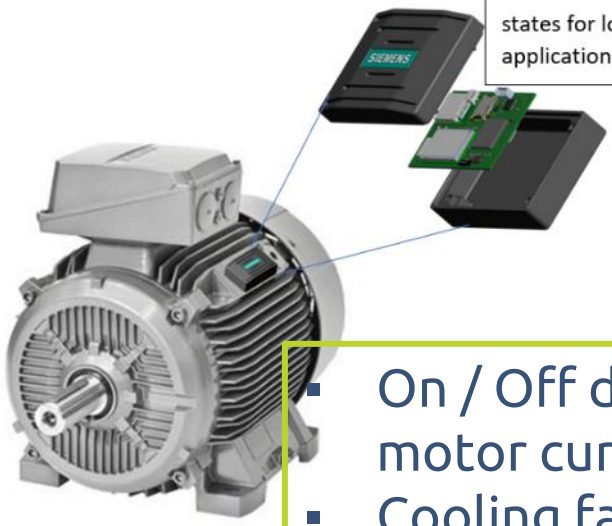
- Control applications need DL-based condition classification
  - On the edge device for low power consum
  - Suggestions for control and maintenance
- DL methods on all communication layers
  - DL in a distributed architecture
  - Dynamically configured systems
- Sensored testbench with 2 motors
  - Acceleration, Magnetic field, Temperature, IR-Cam (temperature), Current-Sensors, Torque

Challenge: Low-power / Efficiency

Edge devices with AI for sensing communication and detection of complex states for local safety and control applications



- On / Off detection without motor current or voltage
- Cooling fault detection
- Bearing fault detection

Demonstrated > 2 years of battery lifetime (> 7x eff. improvement)

Use case: Industrial IoT – Arc detection

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Very Efficient Deep Learning in IoT

- AI based pattern recognition for different local sensor data
  - current, magnetic field, vibration, temperature, low resolution infrared picture
- Safety critical nature
  - response time should be <10ms
  - AI based or AI supported decision made by the sensor node itself or by a local part of the sensor network

Combining the information from the IR-Camera and the magnetic field sensor to localize electric faults in power cabinets by deep learning methods

Specifications:
- Industrial temperature range (-20°C ... +85°C)
- Industrial batteries (rechargeable for ID-Tag)
- IP65 protection
- RoHS and IEC 61850-3 complaint
- Pre-certified wireless transceivers
- Target price: 100€ (ID-Tag)
- SIM on Chip*

Demonstrated > 99 % accuracy (> 20 x eff. improvement)

Challenge: Accuracy

Use case: Smart Mirror – Neural Networks

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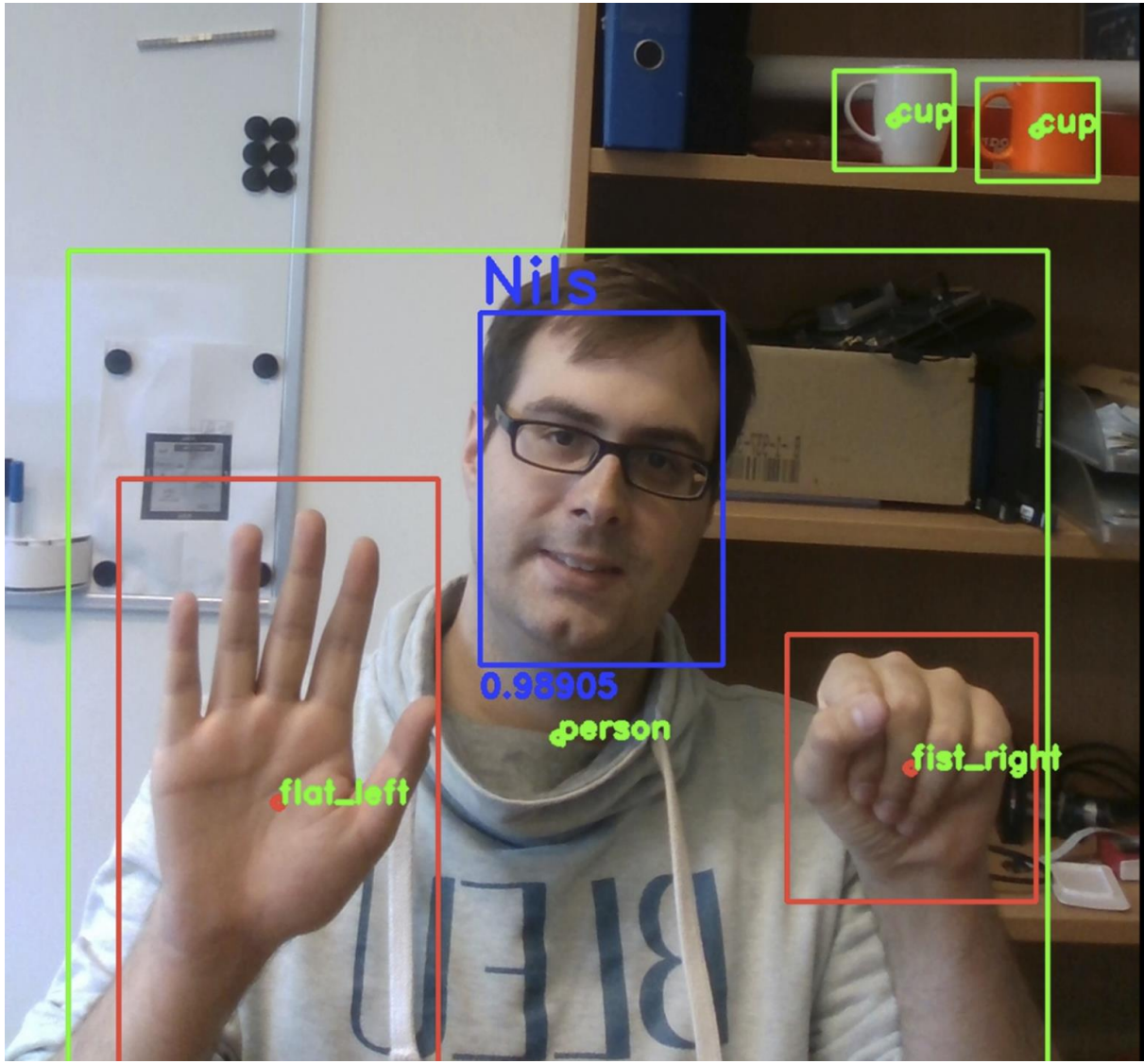
- Face recognition
  - Mobilenet SSD trained on WIDERFACE dataset
- Object detection
  - YoloV3, Efficient-Net, yoloV4-tiny
- Gesture detection
  - YoloV4-tiny with 3 Yolo layers (usually: 2 layers)
- Speech recognition
  - Mozilla DeepSpeech

- AI Art: Style-Gan trained on works of arts
- Collect usage data in situation memory



Challenge: Data privacy, Efficiency

Demonstrated local processing (> 9 x eff. improvement)

Summary

VEDLIoT
Very Efficient Deep Learning in IoT

- VEDLIoT key results
  - Scalable, heterogenous, cognitive IoT hardware platform (Embedded – Edge – Cloud)
  - Full co-design approach, model optimization and extensive benchmarking
  - Secure environment for distributed applications, WebAssembly runtime + Trusted Execution Environment + Distributed (Byzantine fault-tolerant) attestation
  - Demonstrated efficiency improvement of at least on order of magnitude for wide range of use cases

- VEDLIoT lessons learned
  - Heterogeneity and reconfigurability is key for next generation AIoT platforms
  - Toolchain coverage for mapping applications to this heterogeneous hardware is vital
  - Security and robustness are mission critical for a broad spectrum of AIoT applications
  - Systematic requirements engineering for AIoT is vital to meet all requirements complying with regulatory constraints, such as the AI Act.

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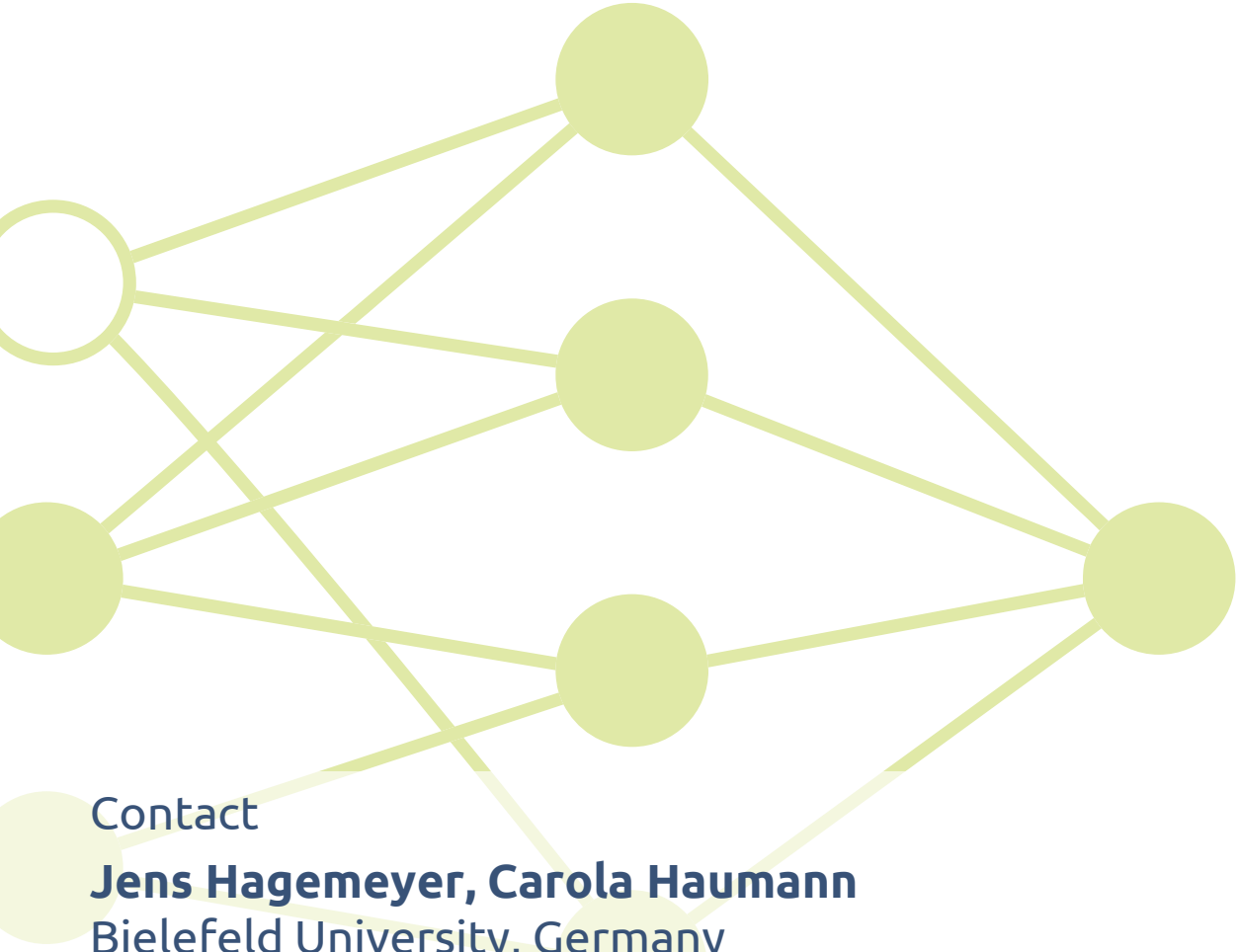

Thank you for your attention.

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