ALOHA

A SOFTWARE FRAMEWORK FOR RUNTIME-ADAPTIVE AND SECURE DEEP LEARNING ON HETEROGENEOUS ARCHITECTURE

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ALOHA – software framework for runtime-Adaptive and secure deep Learning On Heterogeneous Architectures

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Scientific Coordinator

Paolo Meloni - University of Cagliari, EOLAB

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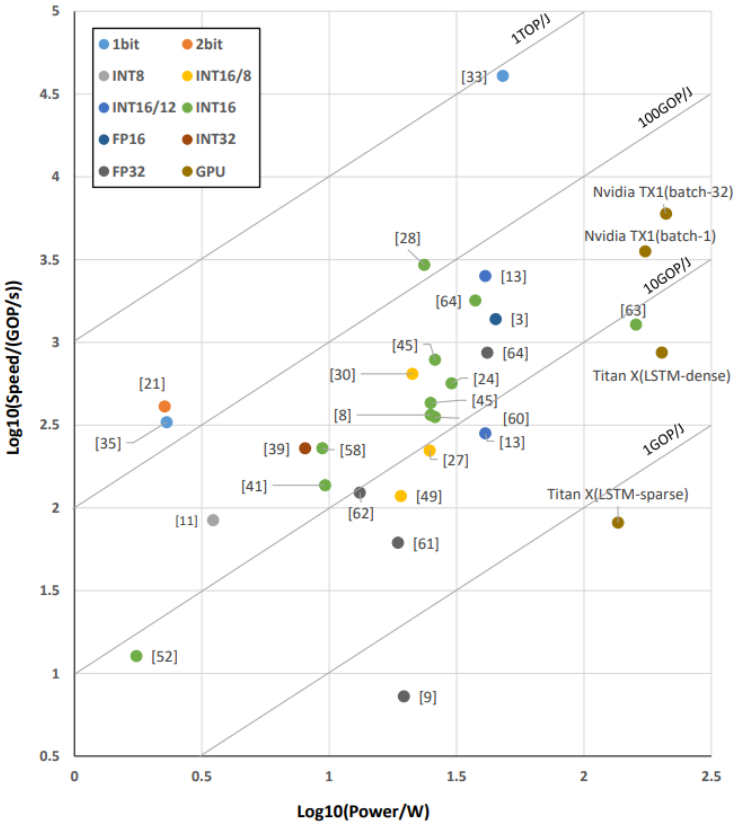
The landscape of DL on embedded Cognitive edge computing

- Increasing number of novel DL models proposed every year
- Increasing size and complexity (generally)



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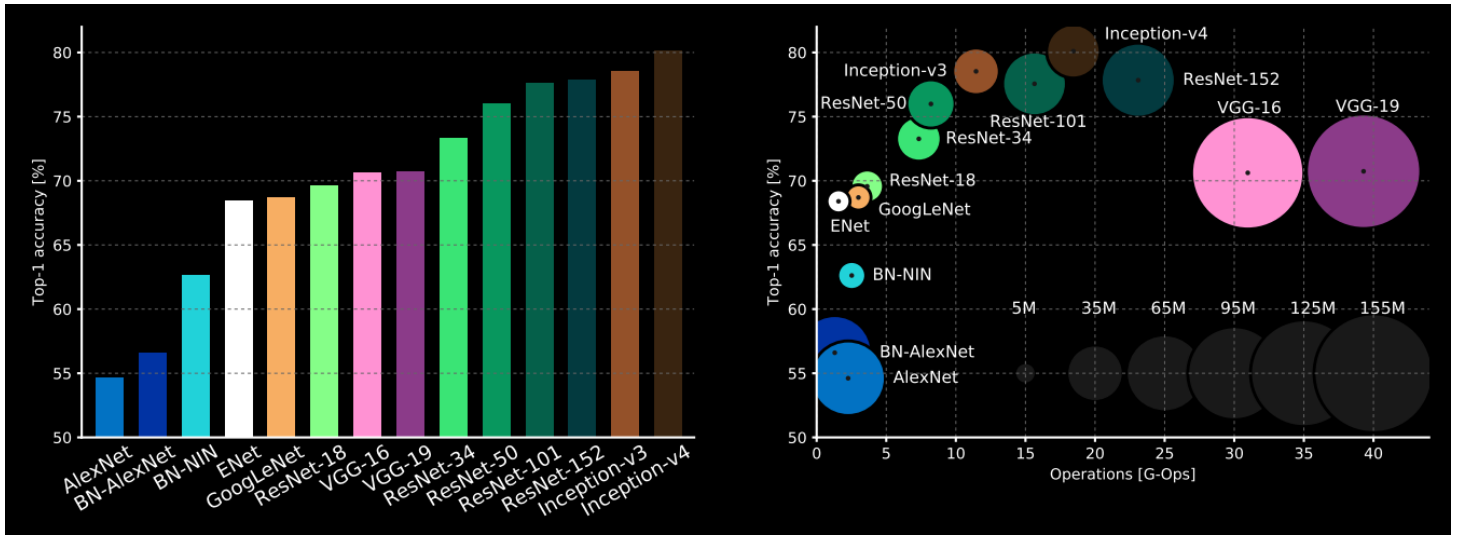
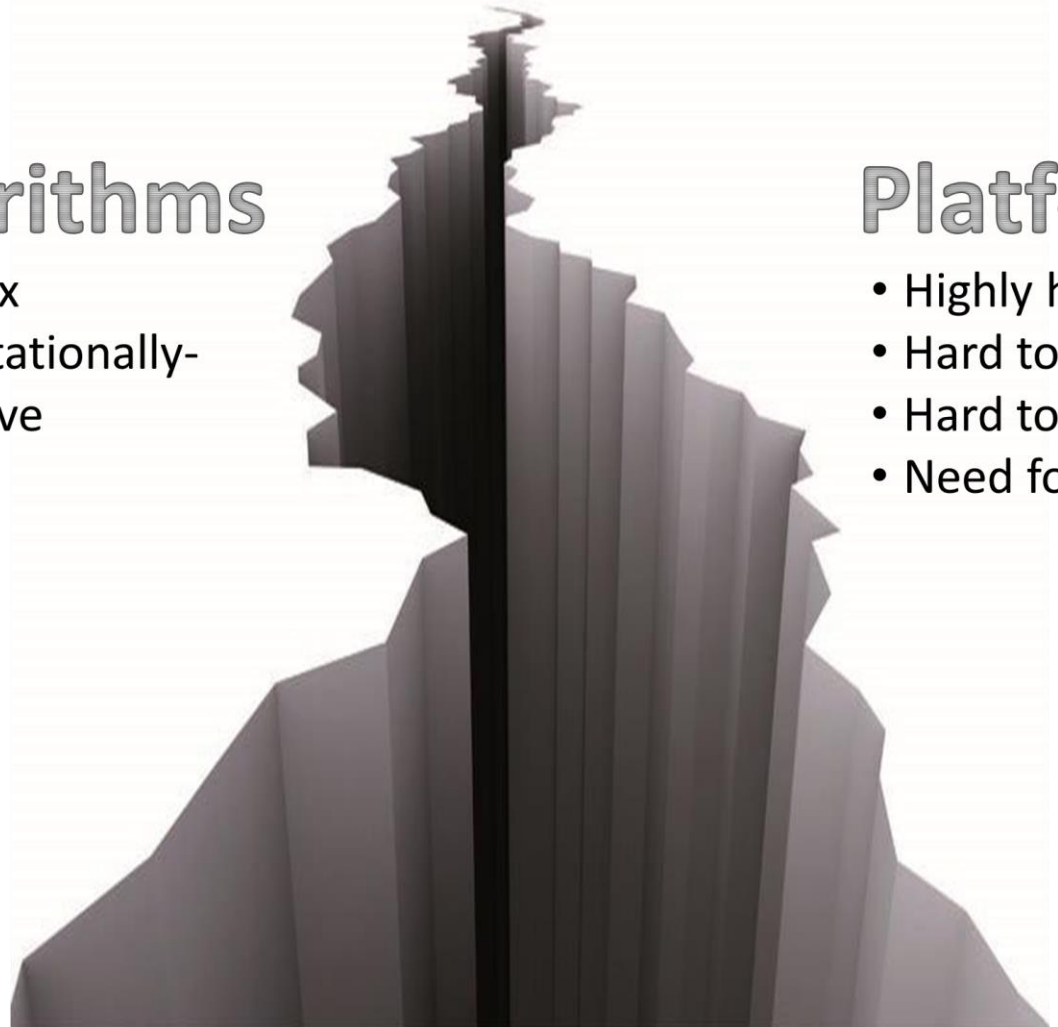


An Analysis of Deep Neural Network Models for Practical Applications A. Canziani, A. Paszke, E. Culurciello, 2016

- Increasing number of DL-supporting computing architectures
- Increasing complexity, parallelism and heterogeneity

Guo et al. - https://arxiv.org/pdf/1712.08934.pdf

The DL dichotomy



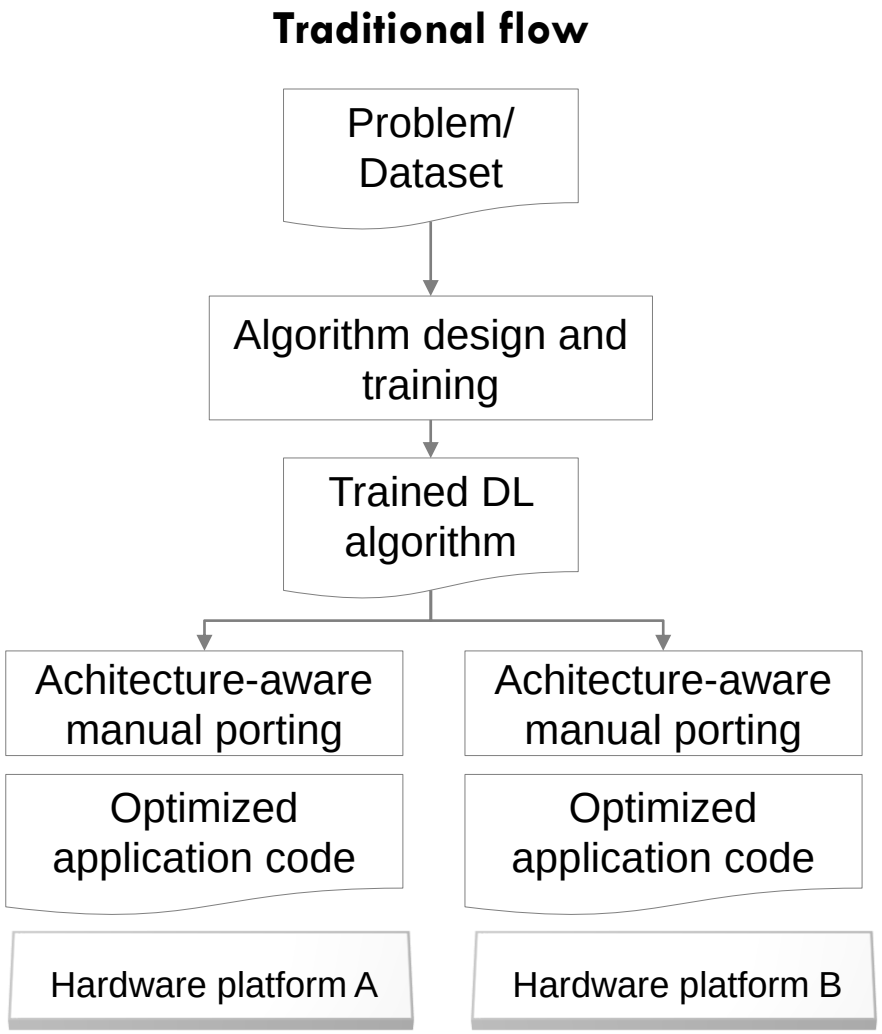
Algorithms

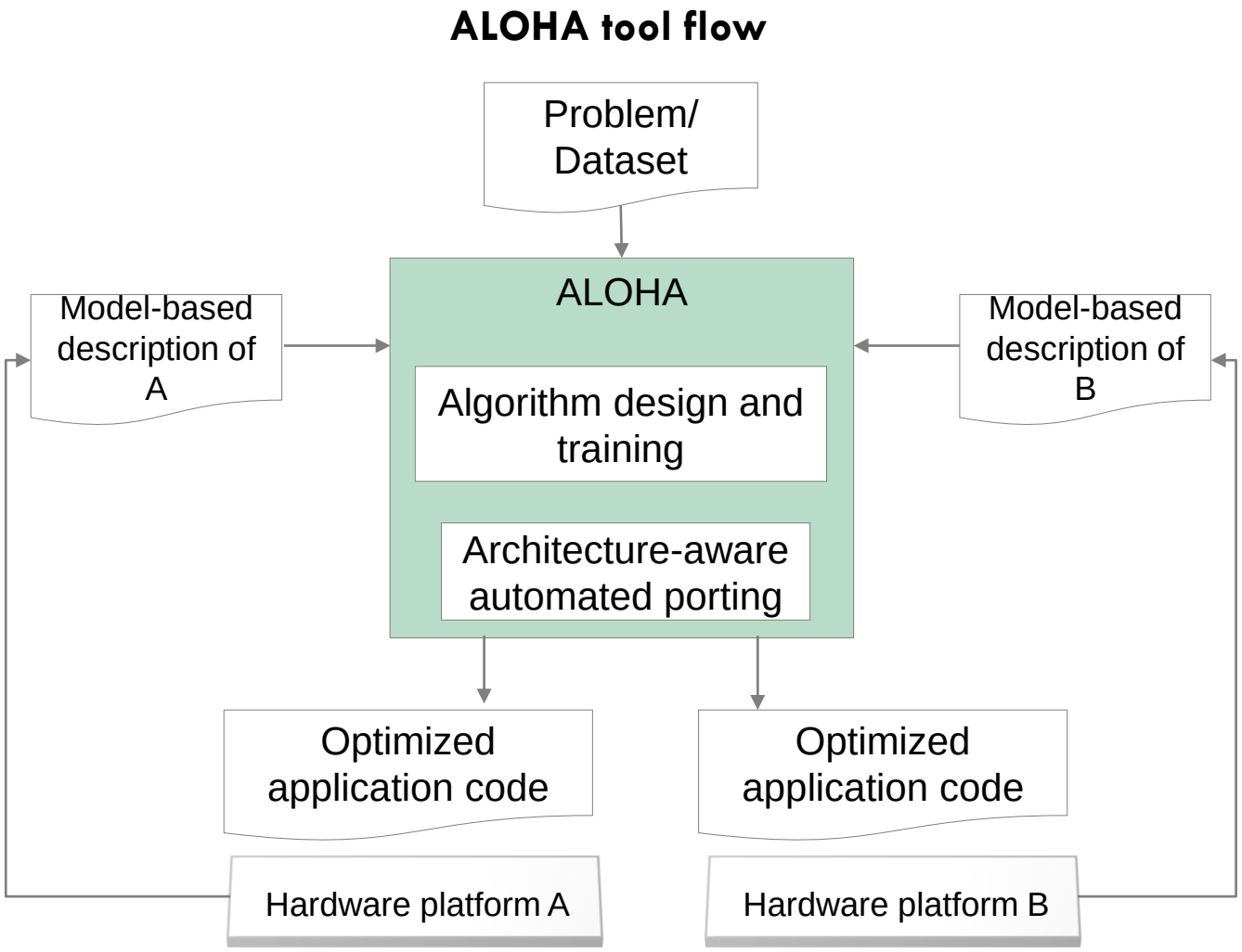
- Complex
- Computationally-expensive

Platforms

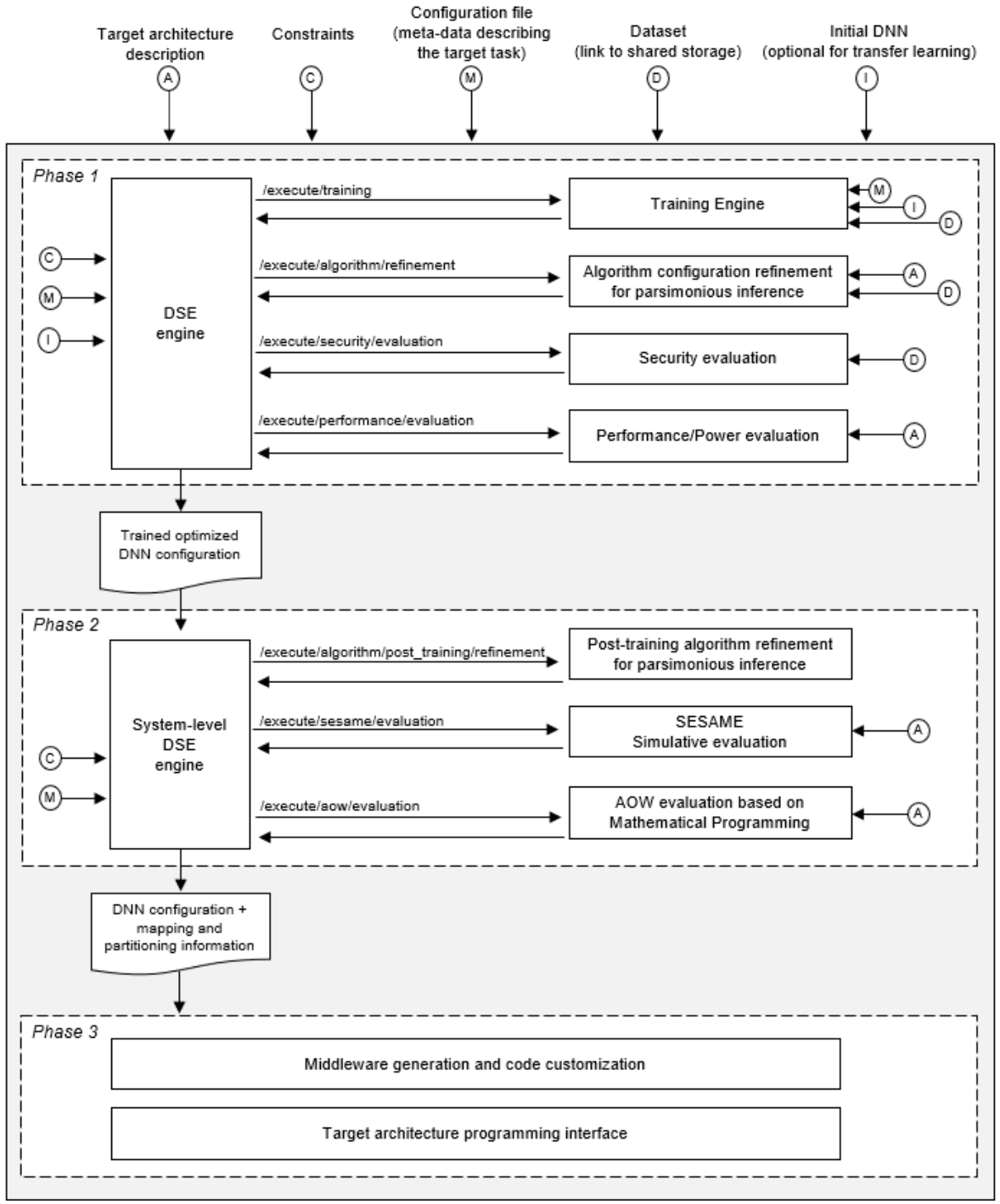
- Highly heterogeneous and parallel
- Hard to program
- Hard to manage at runtime
- Need for low-power

ALOHA: the approach

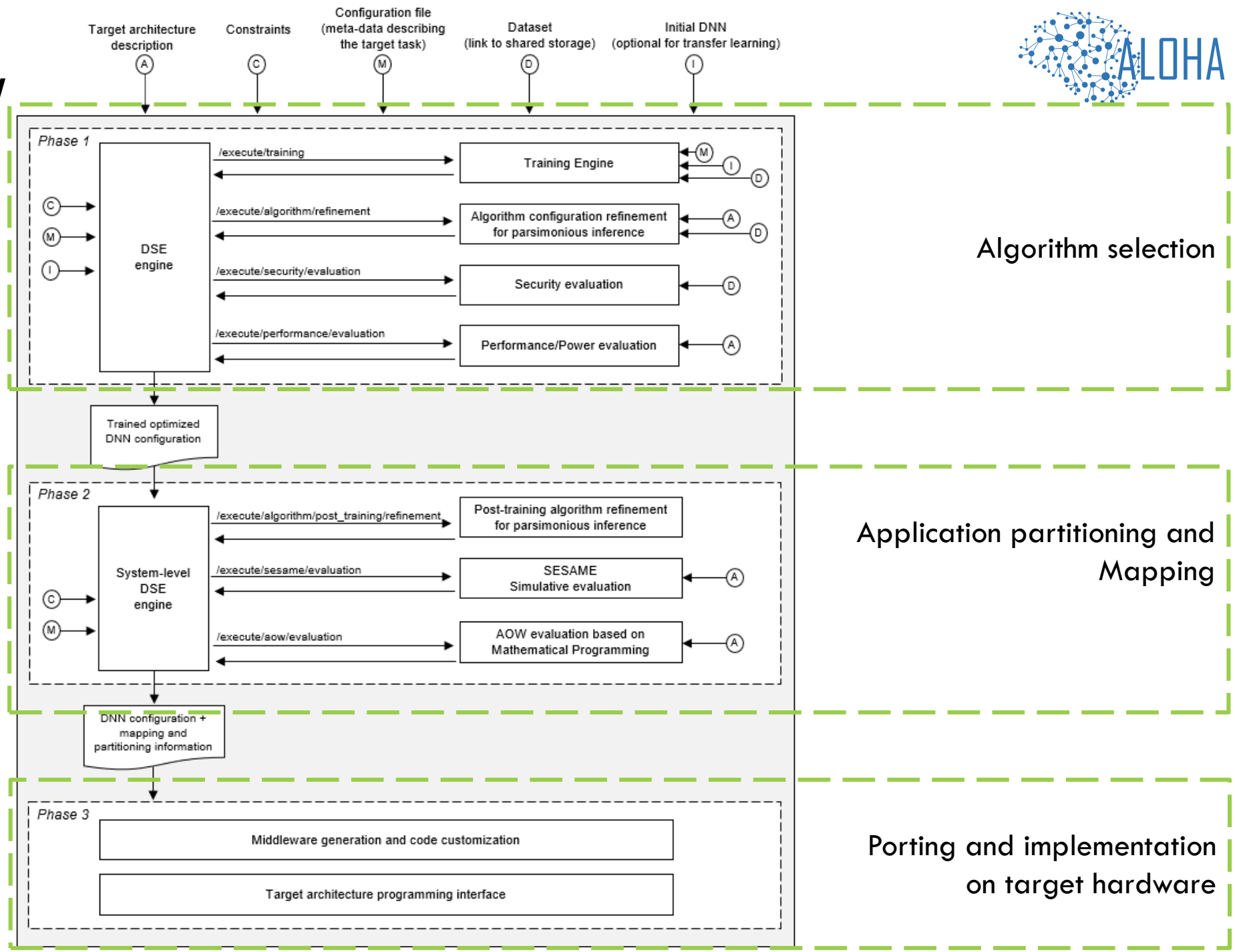




ALOHA Tool flow
General overview



ALOHA Tool flow
General overview



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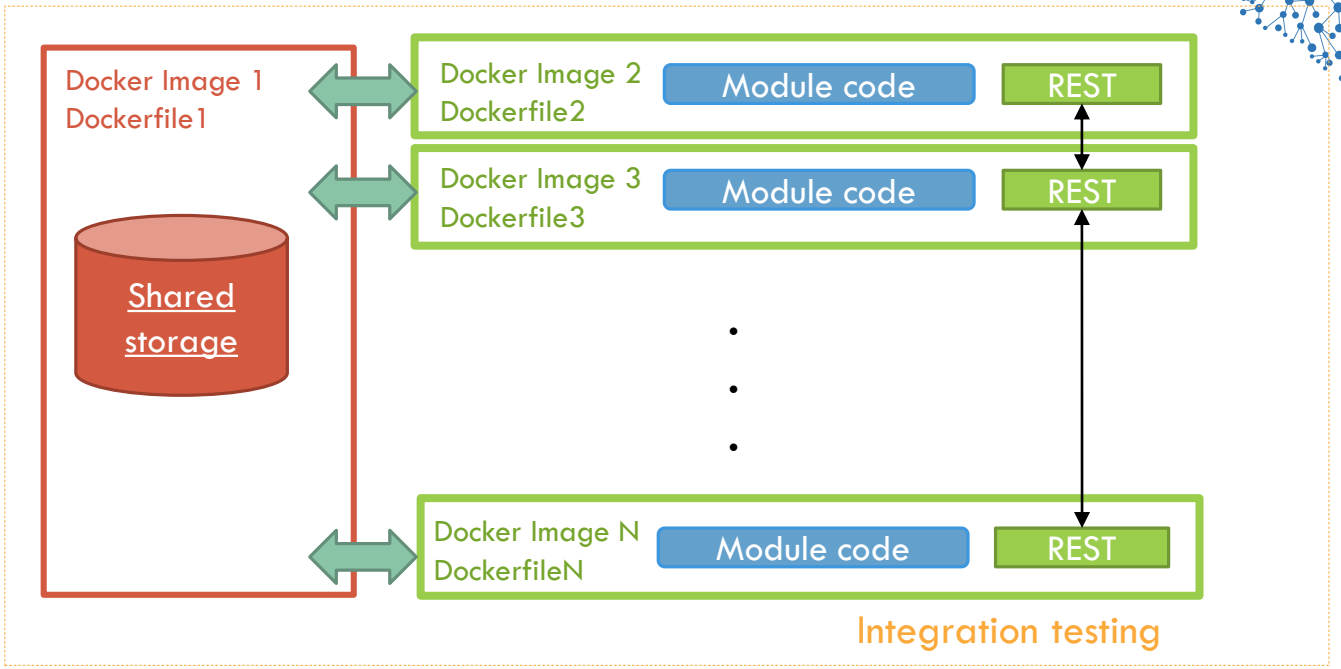
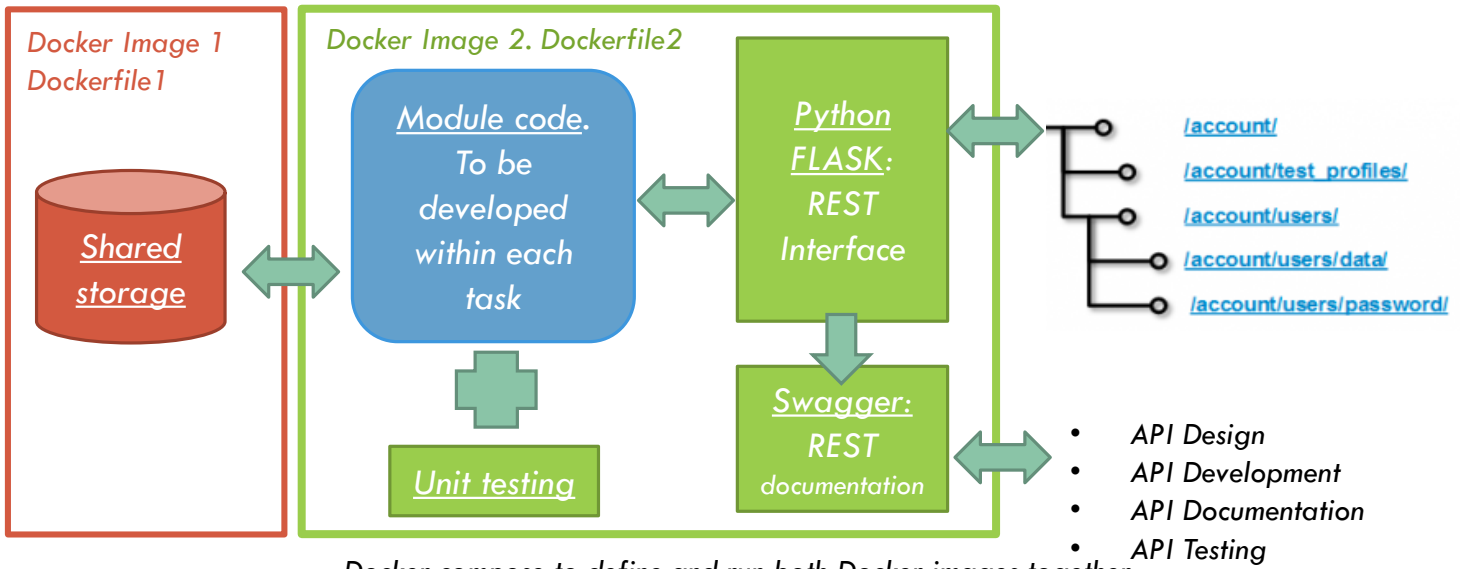
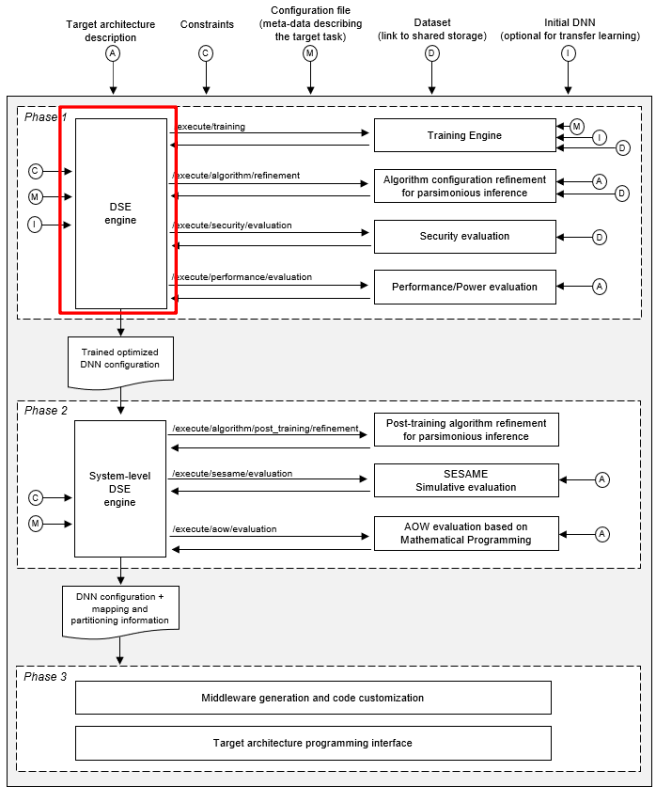
ALOHA Tool flow
Integration methodology

- Components communicate through REST APIs
- Independent containers
- Modularity
- Agile development methodology

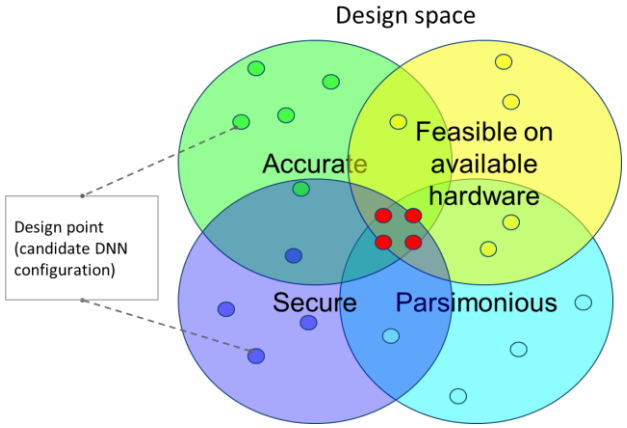




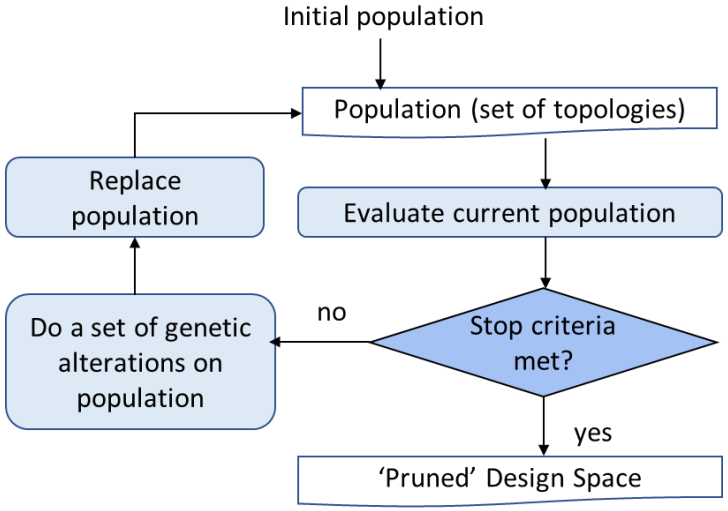
ALOHA Tool flow
The DSE engine



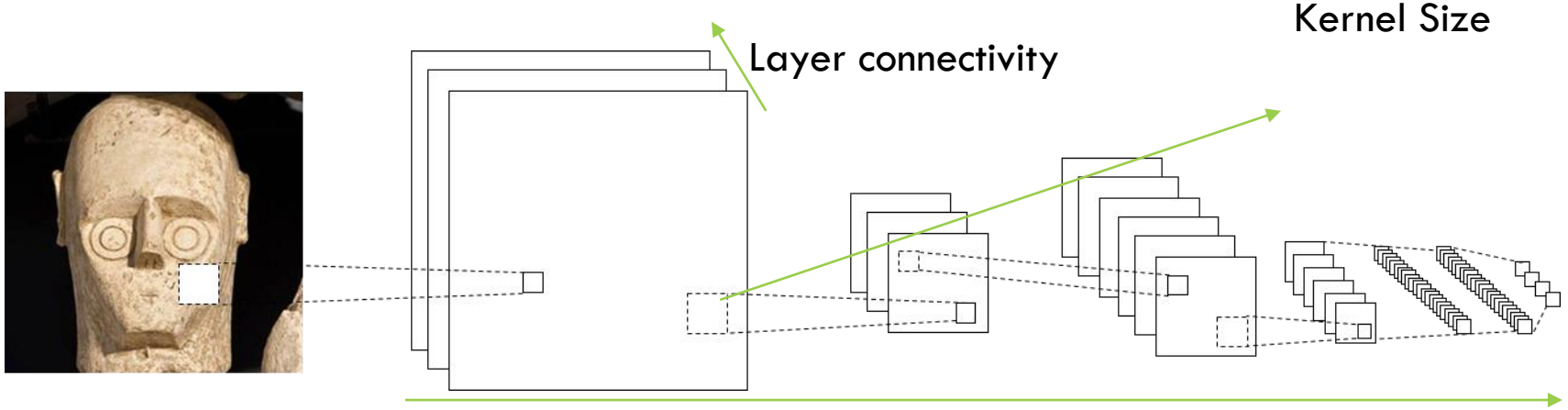
- Multi-objective exploration



- Genetic algorithm DS surfing



- Explore algorithm configuration degrees of freedom



… and others!

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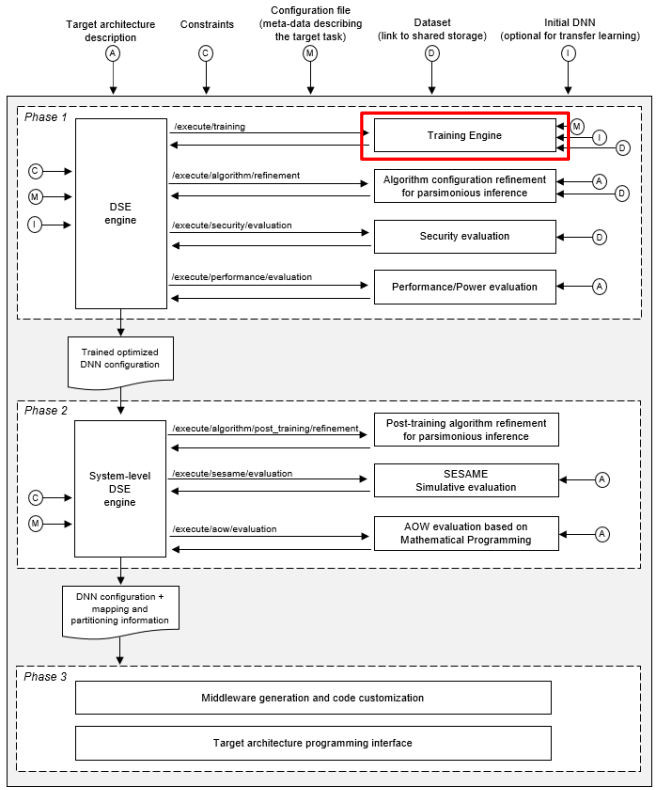
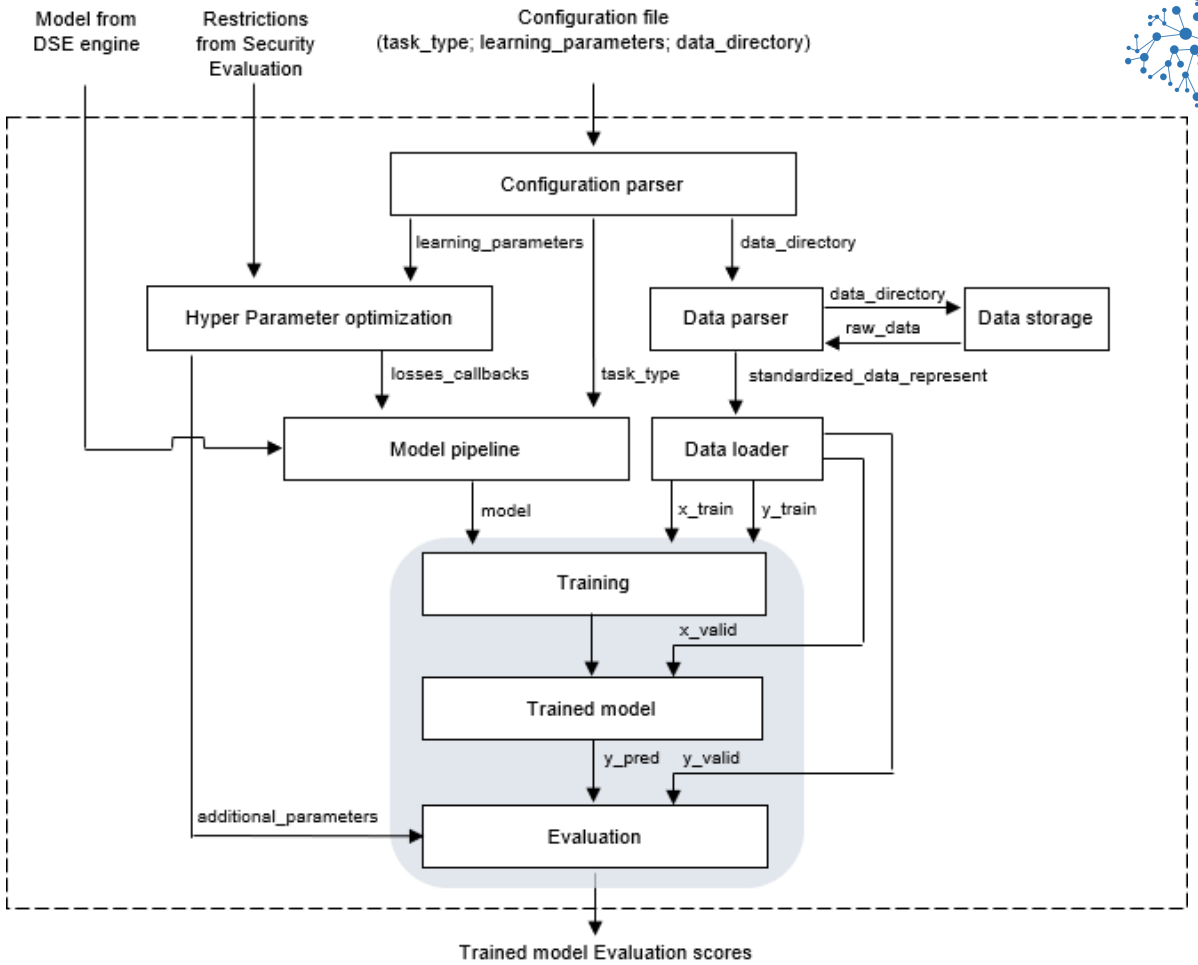
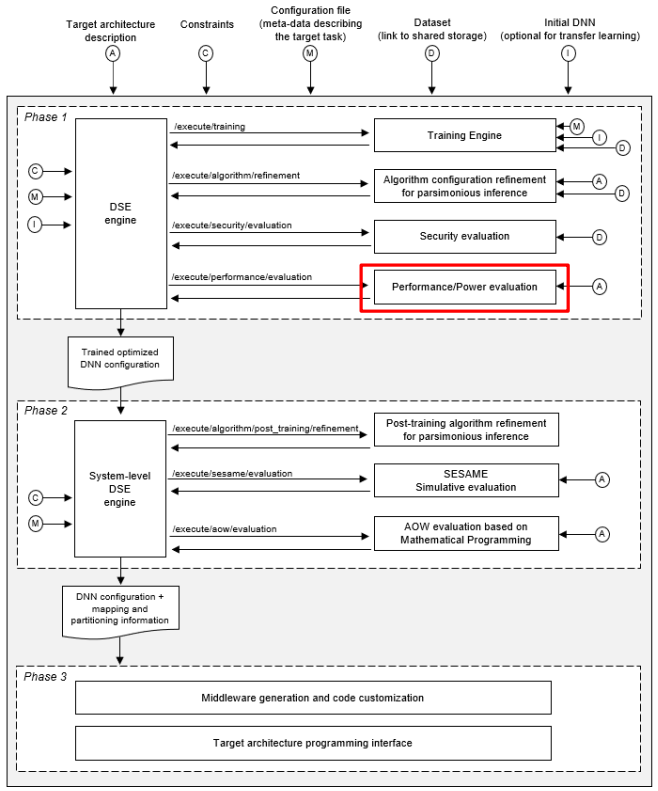
ALOHA Tool flow
The training engine



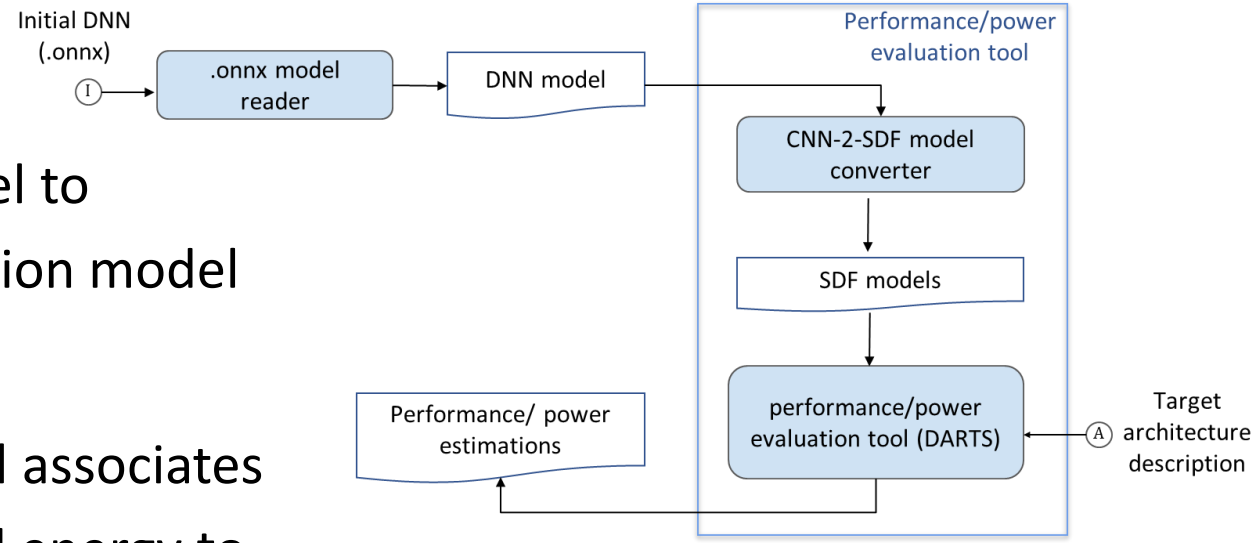


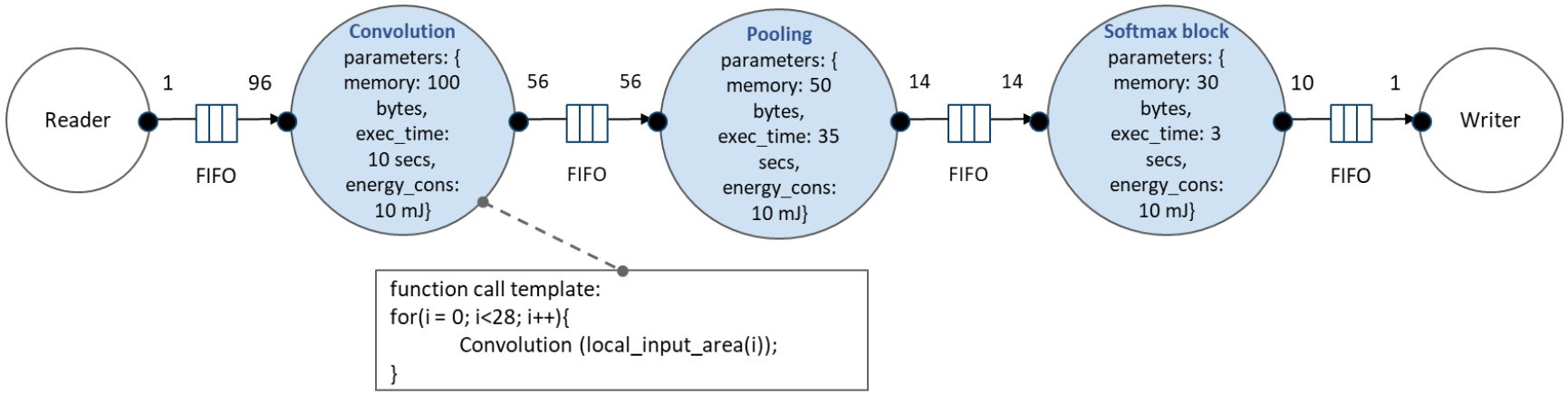
- Transfer learning enabled (reuse of the model in different domains with reduced dataset)
- Local hyperparameter exploration
- Flexible data parsing (multiple input formats)
- Flexible use-case configuration (multiple AI tasks: classification, detection, tracking etc…)

ALOHA Tool flow
Performance/power evaluation

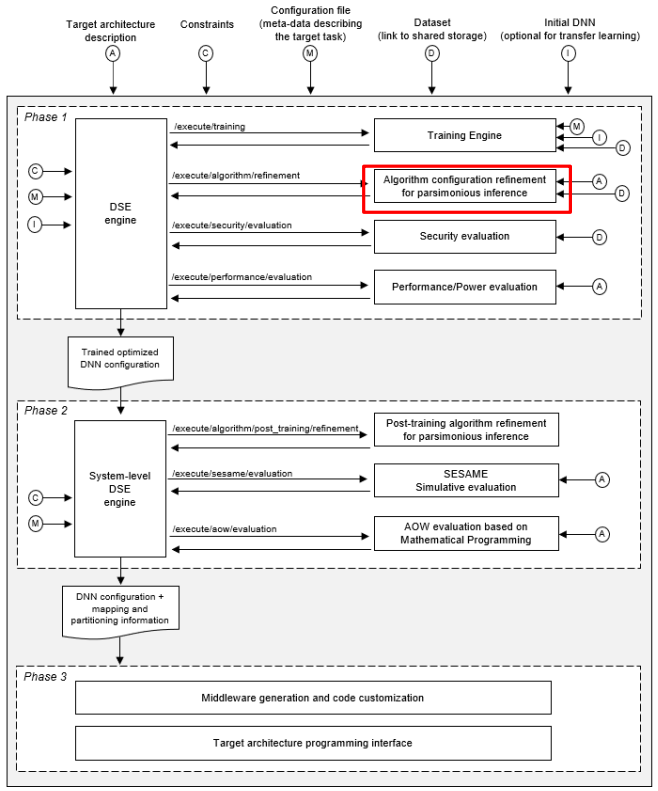


- Convert DNN model to analyzable application model (SDF)
- Architecture model associates execution time and energy to each SDF actor (iteration)
- Analyze/transform/evaluate



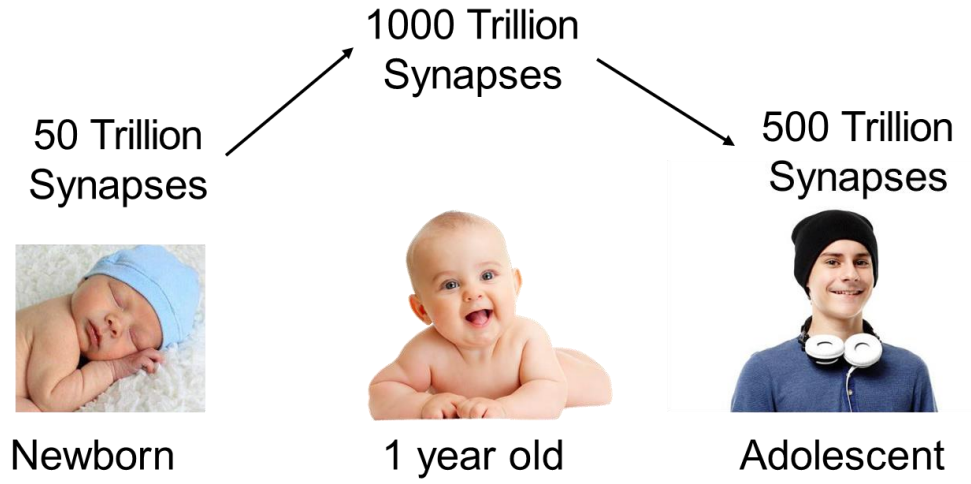


ALOHA Tool flow
Refinement for parsimonious inference



Refine algorithm selection to:

- Reduce computational workload
- Reduce memory footprint
- Reduce IO bandwidth requirements



Christopher A Walsh. Peter Huttenlocher (1931-2013). Nature, 502(7470):172–172, 2013.

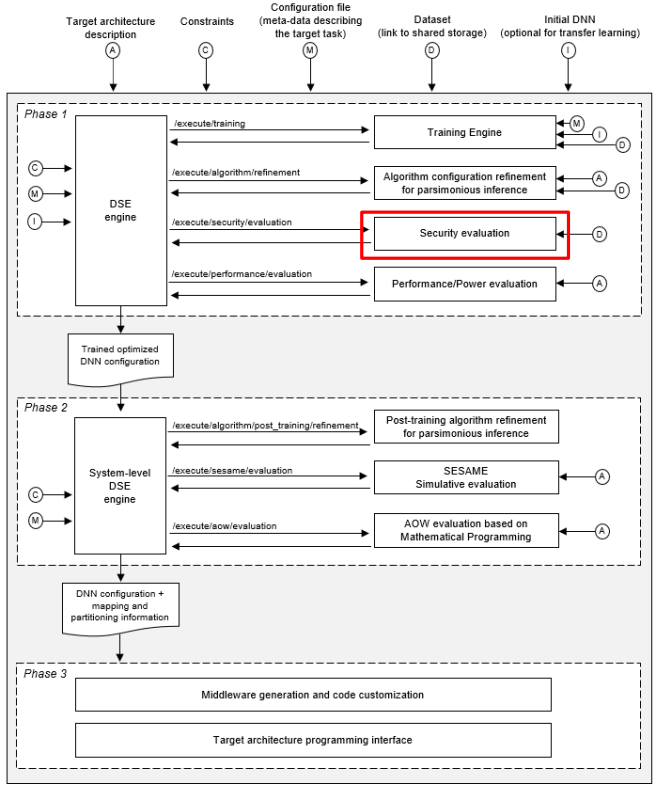
QUANTIZE

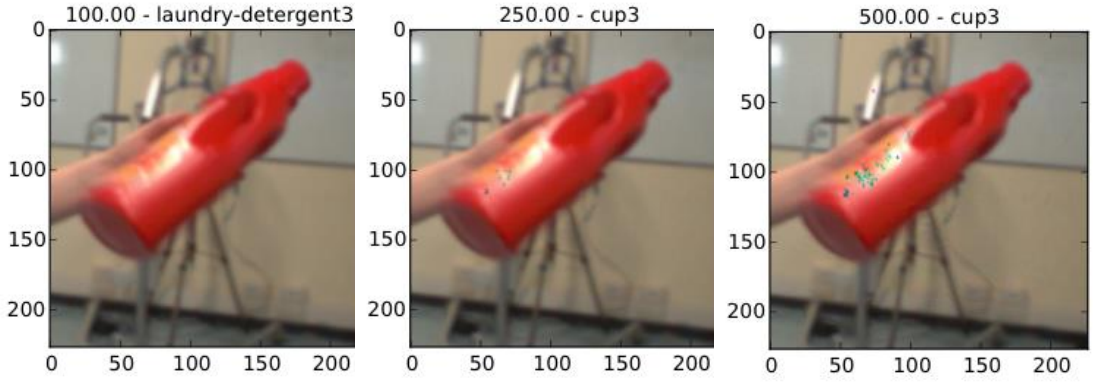
- ***fixed***: low-precision calibration to 16/8 bits
- ***quant_thresh***: quantization to 8/4/2 bits
- *inq*: incremental network quantization
- ***bin***: binarization with XNOR-Net or BNN
- ***abcnet***: binarization with ABC-Net

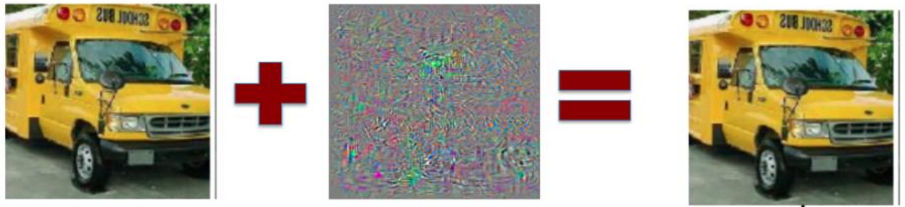
PRUNE

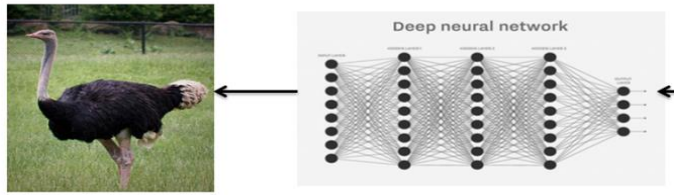
- *prune:* Han et al. iterative pruning of least used connections
- *inq:* pruning together with incremental network quantization

ALOHA Tool flow
Security evaluation

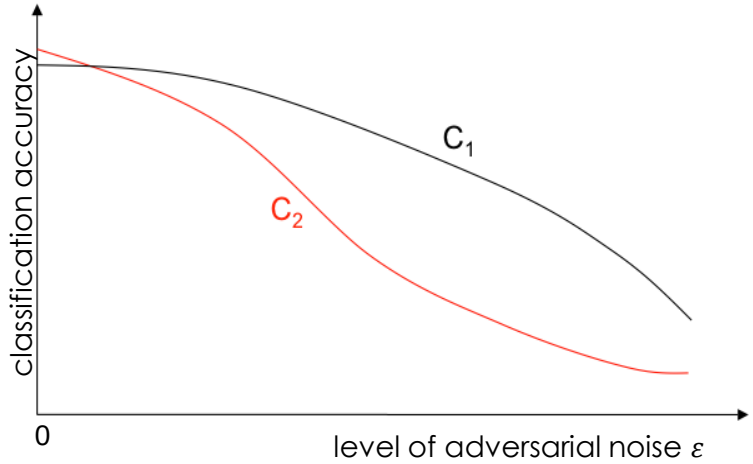








Biggio et al., Evasion attacks against machine learning at test time, **ECML-PKDD 2013**
Szegedy et al., Intriguing properties of neural networks, **ICLR 2014**



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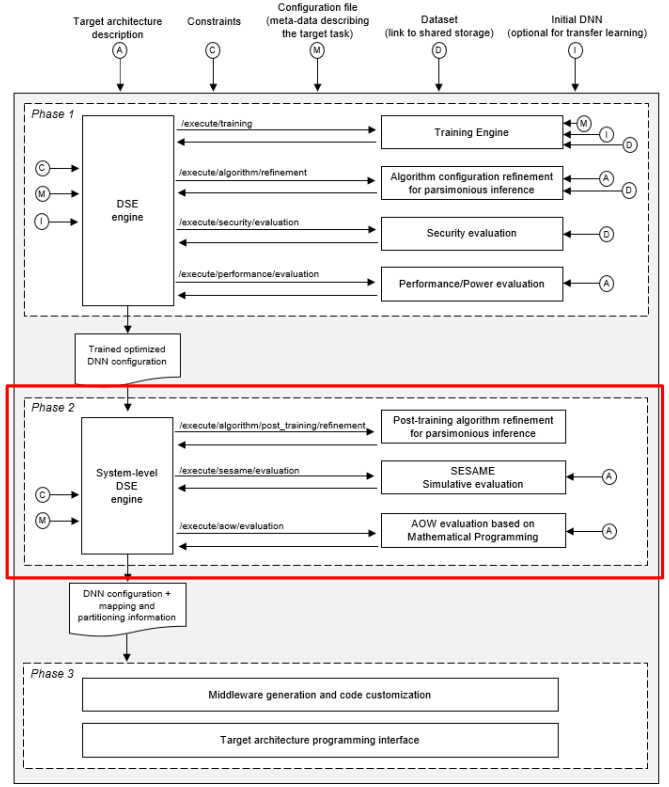
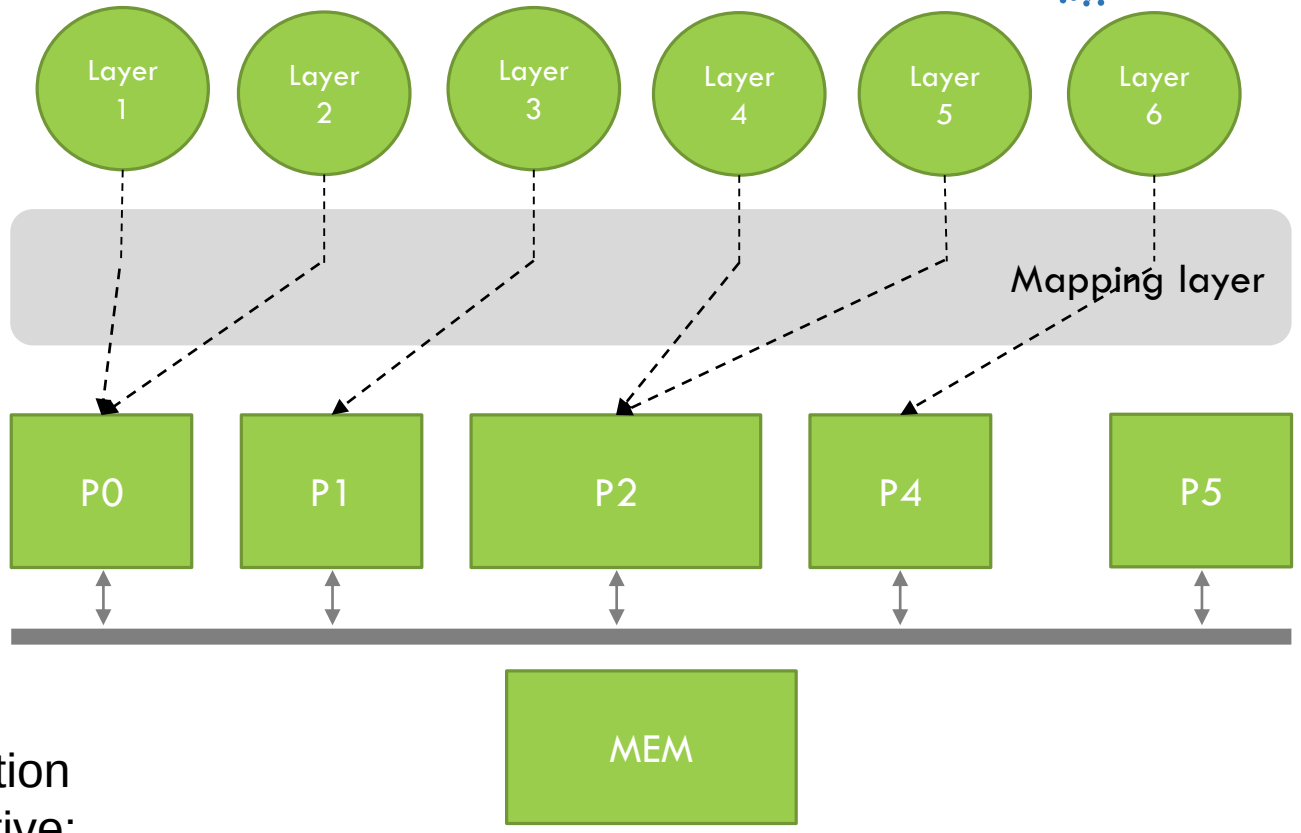
ALOHA Tool flow
Phase 2: system-level design





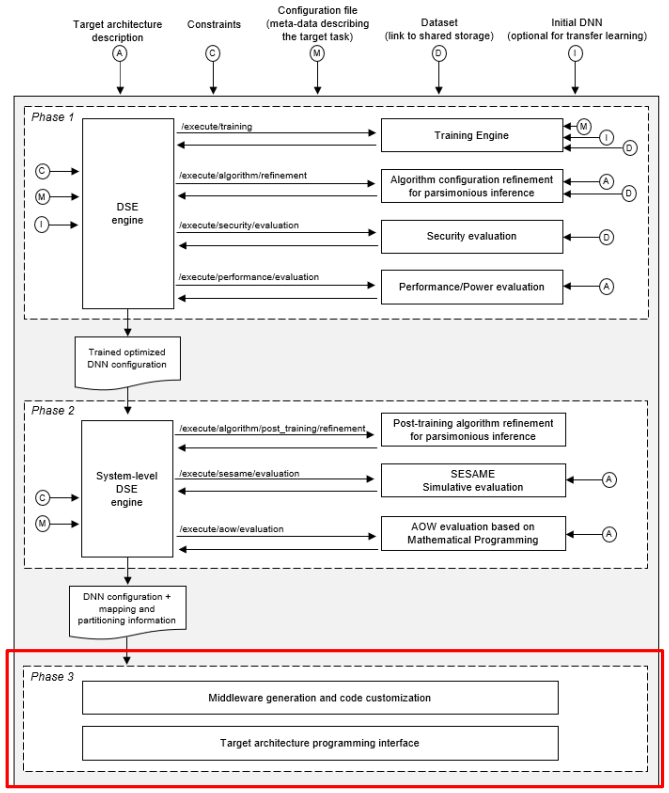
- DSE instrument: Genetic Algorithm

- Design point evaluation
  a) High-level simulative:
  SESAME by UvA (previously on www.madnessproject.org)
  http://sesamesim.sourceforge.net/

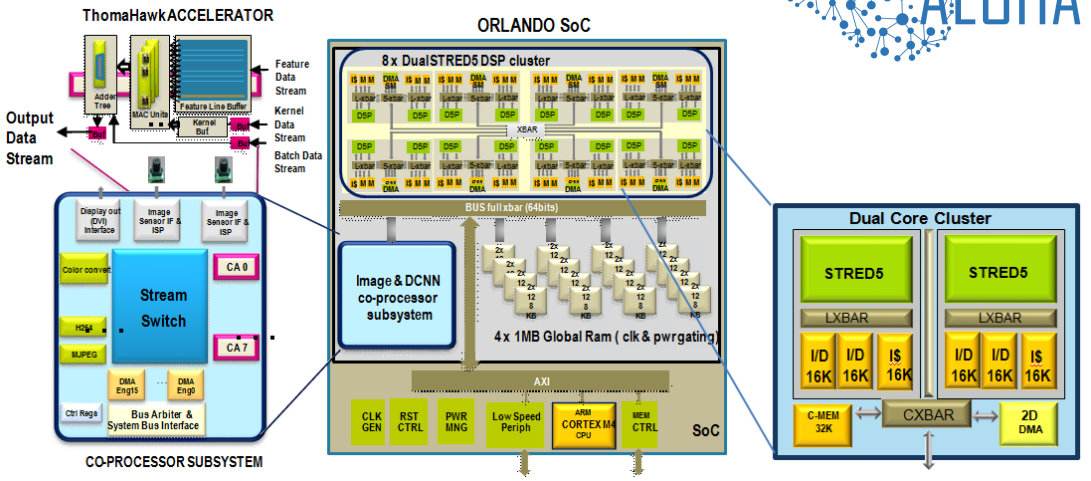
  b) Mathematical Programming and analytic modeling:
  Architectural Optimization Workbench by IBM
  Michael Masin et al. -Pluggable Analysis Viewpoints for Design Space Exploration, 2013

- Post-training parsimonious inference enabled – runtime network modification

ALOHA Tool flow
Reference computing platforms

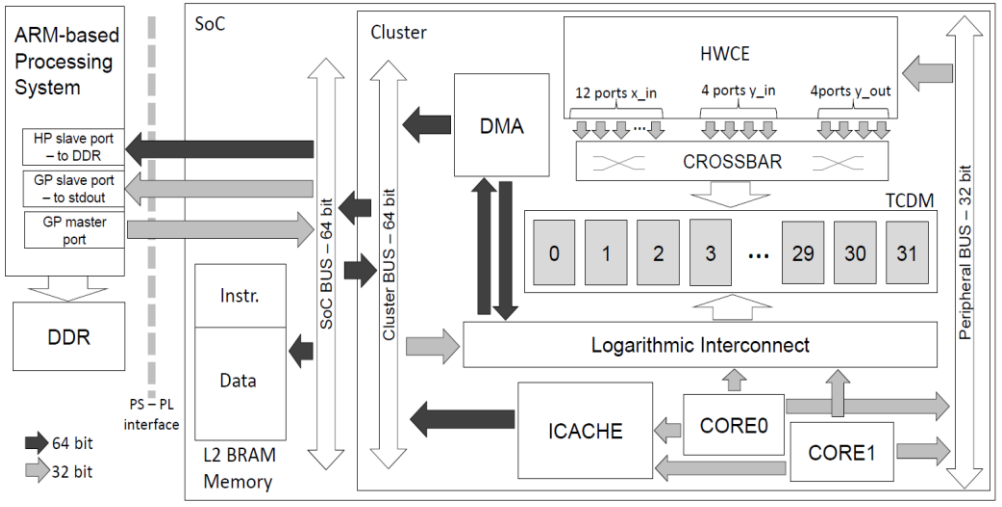


STMicro's Orlando



G. Desoli/et al/., **"14.1 A 2.9TOPS/W deep convolutional neural network SoC in FD-SOI 28nm for intelligent embedded systems"**, 2017 IEEE International Solid-State Circuits Conference (ISSCC), San Francisco, CA, 2017, pp. 238-239. doi: 10.1109/ISSCC.2017.7870349

NEURAghe



P. Meloni, A. Capotondi, G. Deriu, M. Brian, F. Conti, D. Rossi, L. Raffo, L. Benini, **"NEURAghe: Exploiting CPU-FPGA Synergies for Efficient and Flexible CNN Inference Acceleration on Zynq SoCs"**, 2017, https://arxiv.org/abs/1712.00994

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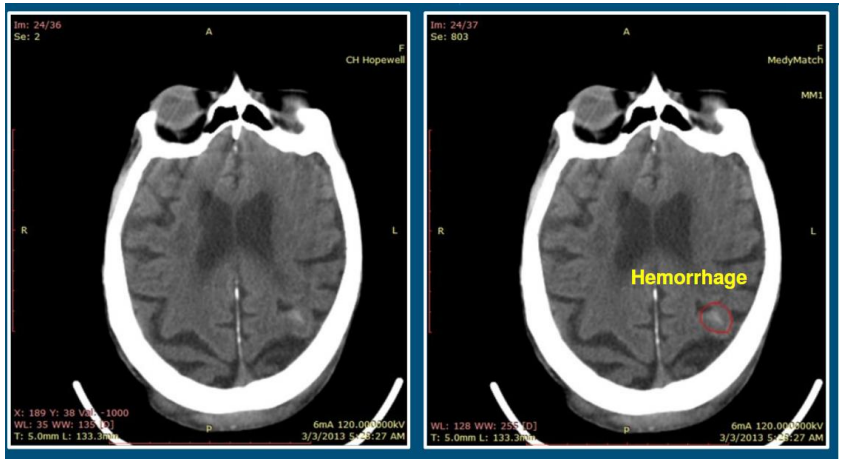
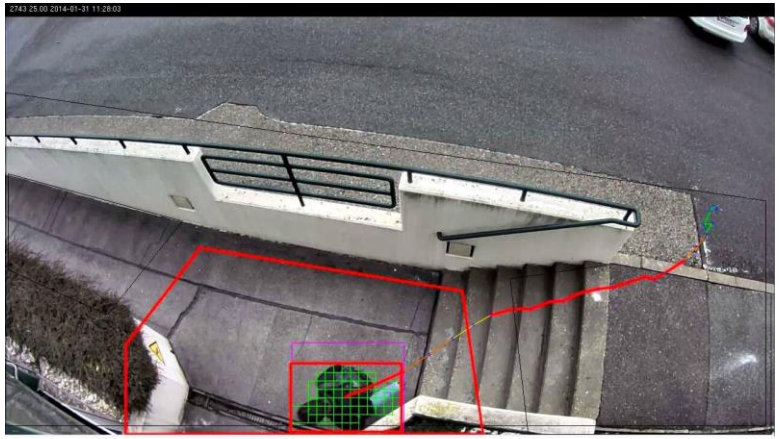
ALOHA use-cases

Demonstration on three application use-cases



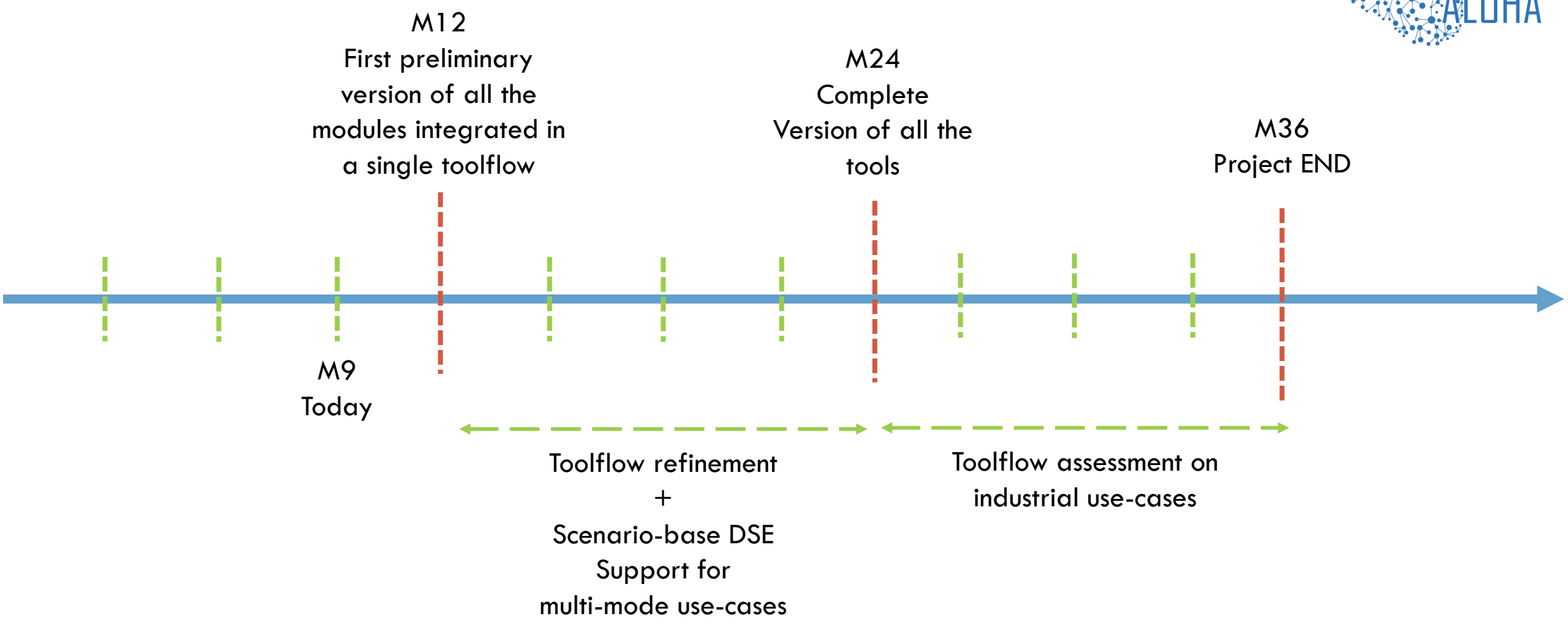
Cost- and power-effective medical decision assistant

Command Recognition in Smart Industry Applications



Surveillance of Critical Infrastructures

ALOHA status



THANK YOU FOR YOUR ATTENTION!

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ALOHA project

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