tinyML® Foundation

Enabling Ultra-low Power Machine Learning at the Edge

tinyML 2.0:
celebrating 5th Year of tinyML and the road ahead!

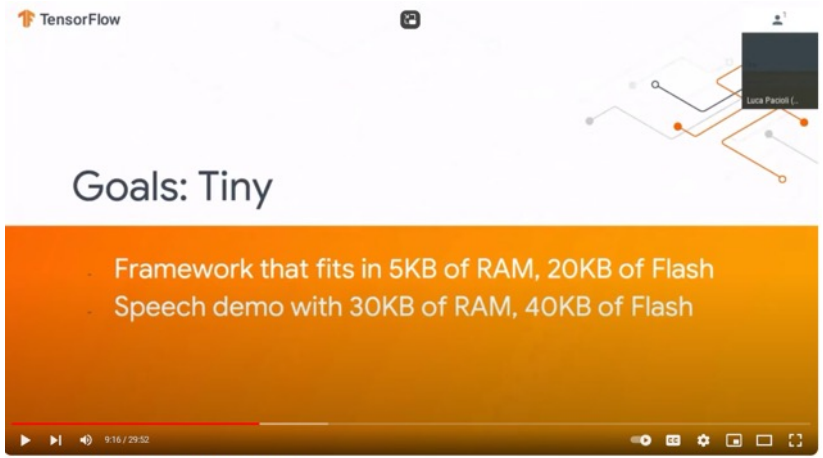
Evgeni Gousev, *Senior Director, Qualcomm AI Research & tinyML Foundation BoD Chair*

www.tinyML.org

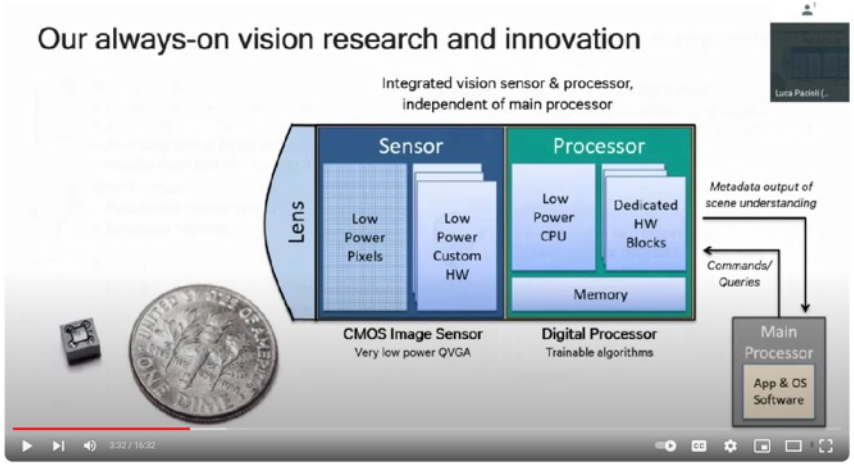
Happy 5th Birthday tinyML !

It all started with an INSPIRATION!

- can one run ML on a tiny (MCU-like) device ?



tinyML Summit 2019 - Pete Warden : TF-lite for tinyML



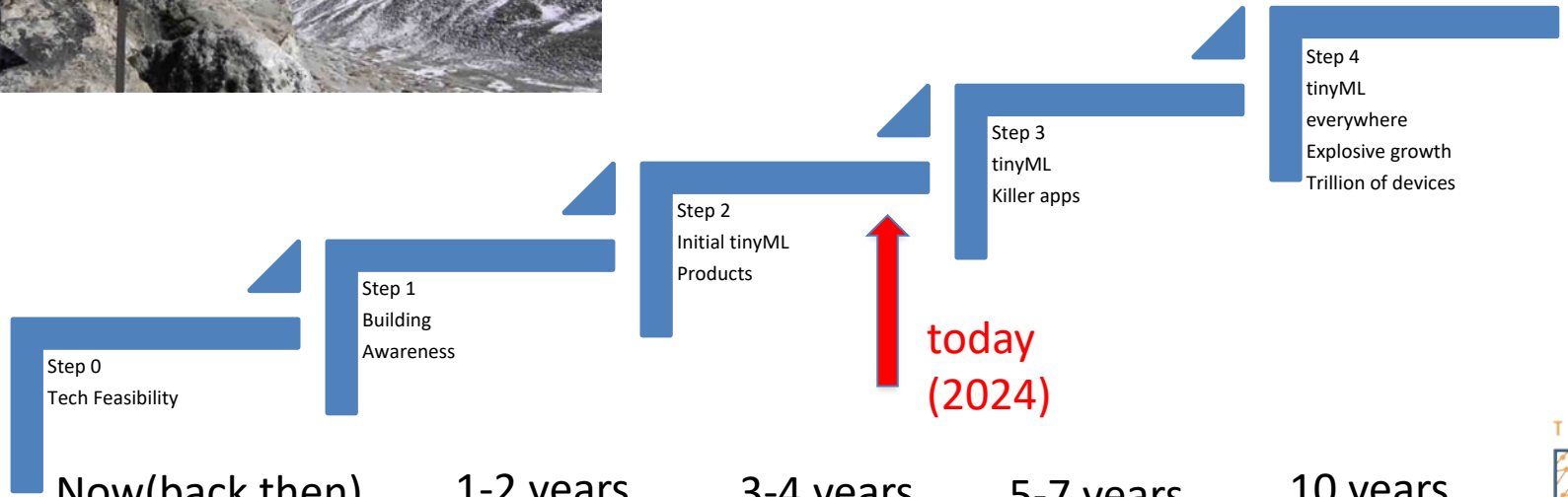
tinyML Summit 2019 - Edwin Park : Ultra-low Power Always-On Computer Vision

Pete Warden, Google

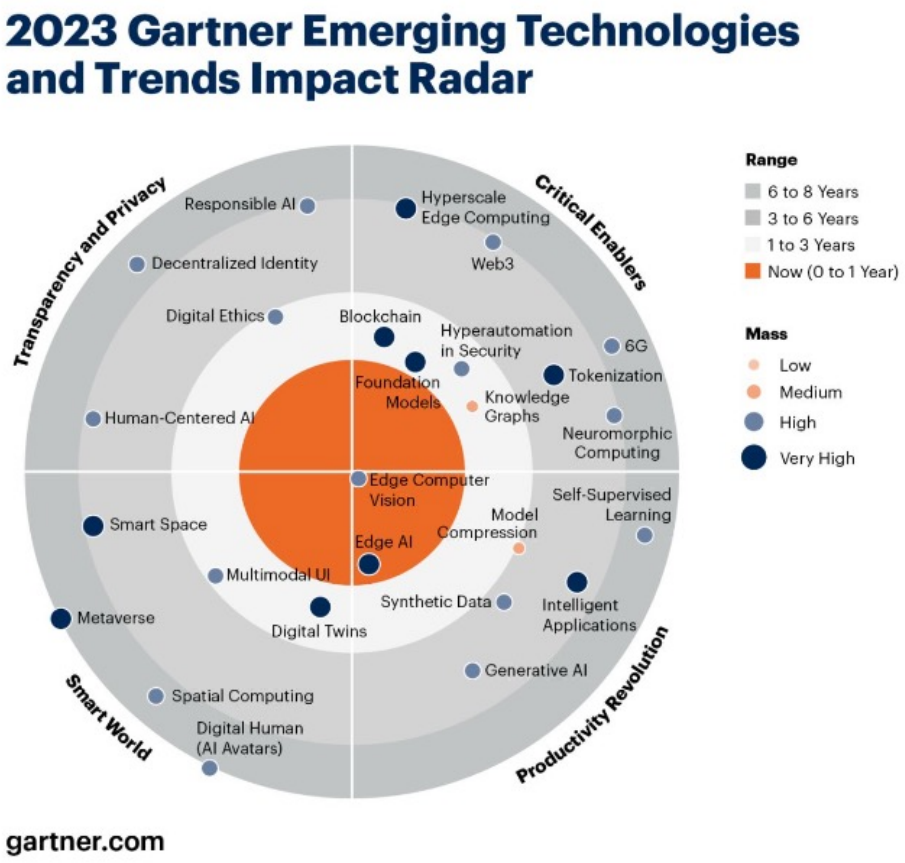
Edwin Park, Qualcomm

from 1st tinyML Summit 2019

Climbing up tinyML mountain *(from 1st, 2019 Summit)*



Edge AI is happening now!

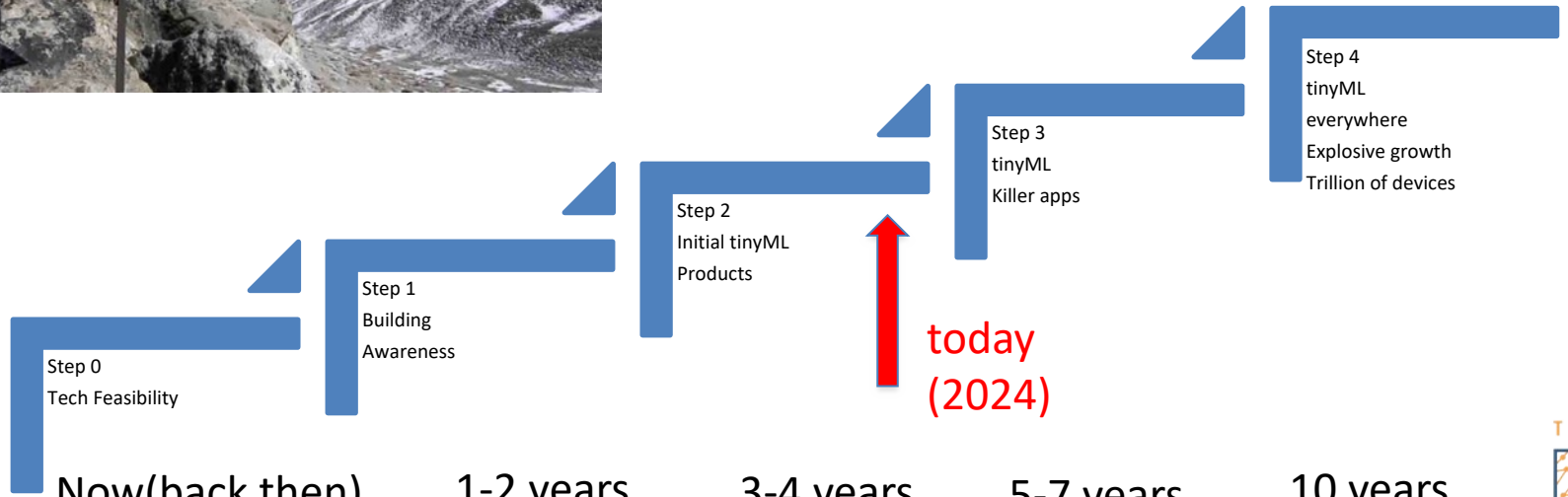


tinyML Community

- 21k+ tinyML meetup members in 50 groups in 41 countries
- 13.2k youtube.com/tinyML subscribers, 704 videos, all FREE, 500k views
- 5k members + 16k followers on LinkedIn
- Massive educational initiative, tinyMLedu (e.g. ~100k students in edX)
- ~ 100 sponsors; amazing diversity

Sponsors & Partners Make It Possible!

Climbing up tinyML mountain *(from 1st, 2019 Summit)*



The Future is at hand !

Emergence of GenAI on the Edge!

=

Released July 18, 2023

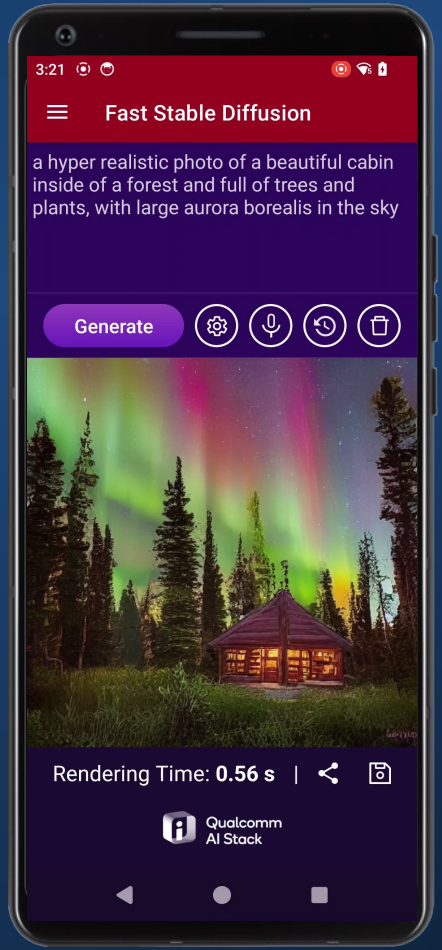
Released April 18, 2024

10x model size reduction in 9 months !

and

you can run it on a Raspberry Pi!

World's fastest AI text-to-image generative AI on a phone



Takes less than 0.6 seconds for generating 512x512 images from text prompts

Efficient UNet architecture, guidance conditioning, and step distillation

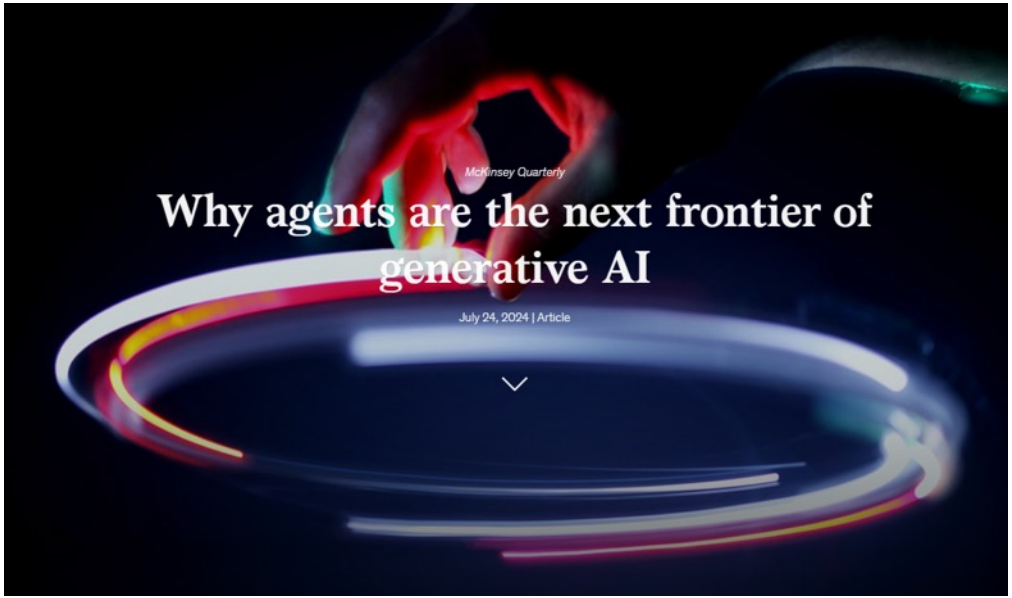
Full-stack AI optimization to achieve this improvement

SLMs will bring SUPERIOR capabilities to the EDGE

“Clem Delangue, CEO of HuggingFace, suggested that

- **up to 99% of use cases could be addressed using SLMs, and**
- **predicted 2024 will be the year of the SLM.”**

Emergence of “agentic” system

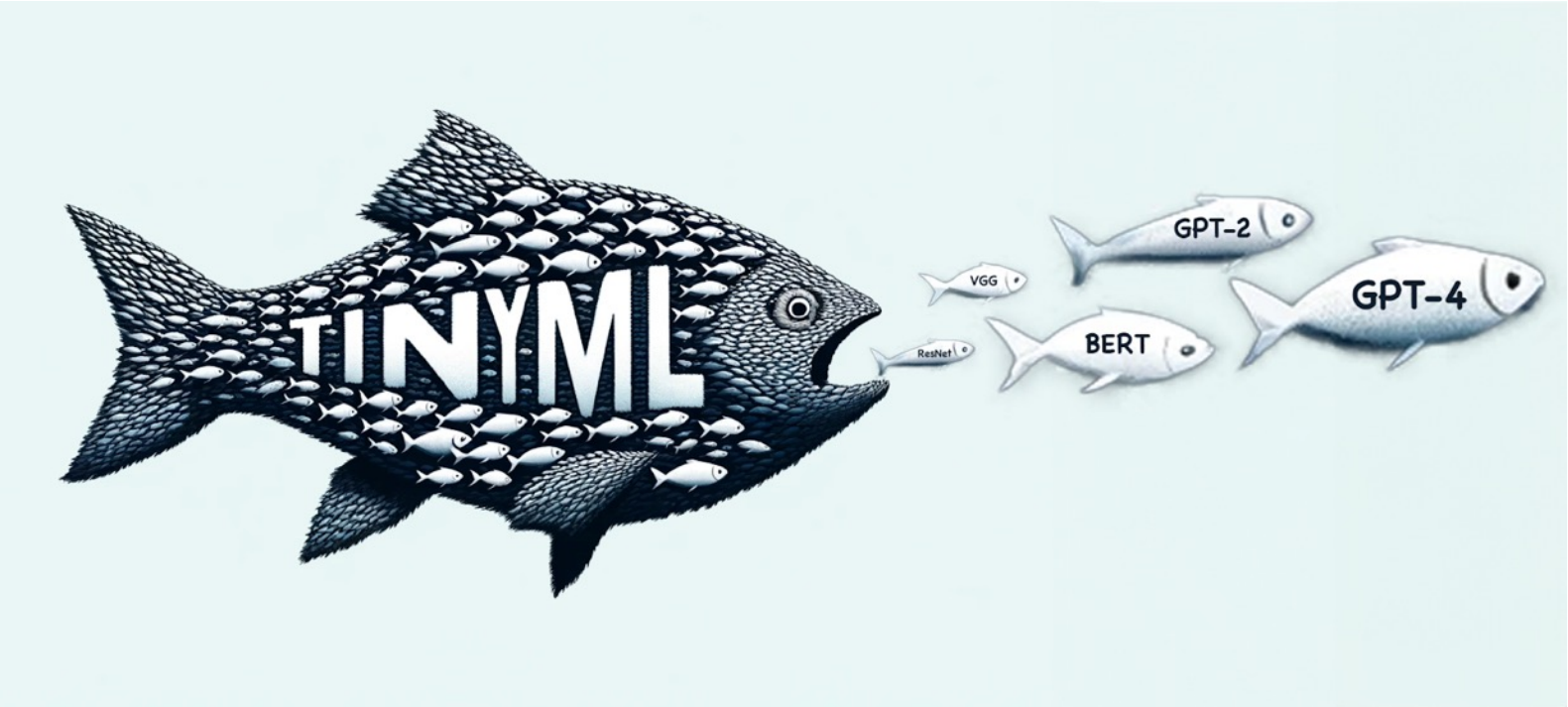


Broadly speaking, “agentic” systems refer to digital systems that can independently interact in a dynamic world

By moving **from information to action**—think virtual coworkers able to complete complex workflows—the technology promises a new wave of productivity and innovation.

Source: www.mckinsey.com (July 24, 2024)

Approaching inflection point for tinyML/edgeAI



Courtesy: Prof. Vijay Reddi and his Harvard team

PETE WARDEN'S BLOG

Ever tried. Ever failed. No matter. Try Again. Fail again. Fail better.

HOME ABOUT

Doom, Dark Compute, and AI

JANUARY 5, 2024
By Pete Warden
in UNCATEGORIZED
Tags: AI, ARTIFICIAL-INTELLIGENCE, COMPUTER, PROGRAMMING, TECHNOLOGY
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Doom, Dark Compute, and AI

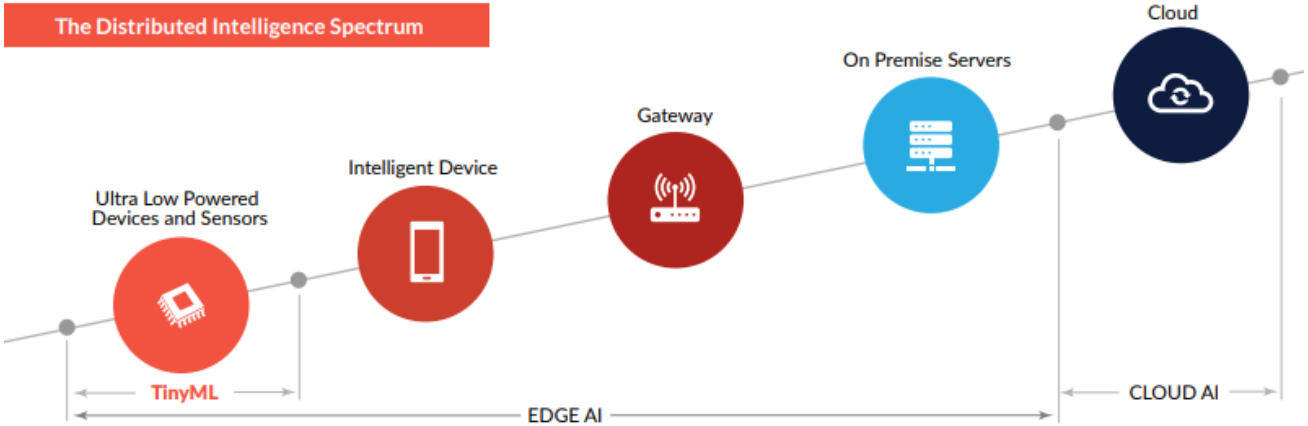
Why I Love my Chevy Bolt EV

Stanford's HackLab Course

<u>Rough estimate:</u>
100 B MCU devices @ 100 MHz = 1E22 TOPS (Int8)
2x greater than today's world's GPU/TPU capacity

TINY ML

Distributed Intelligence at the Edge



Source: ABI Research, TinyML: The Next Big Opportunity in Tech and MD-AIML-107, 2 QTR 2021

Why tinyML Foundation?
Edge AI is Accelerating Digital Transformations

- Advances in semiconductors, connectivity and software have enabled a wave of AI on devices that securely connect to the cloud
- These capabilities are digitally transforming healthcare, agriculture, manufacturing, retail and many more…
- They take the form of low power sensors, cameras/imaging devices, gateways and robotics platforms – running AI Models with cloud-to-edge management and security

Why tinyML Foundation?
The State-of-the Art is Moving Quickly

- AI models can run as small as 5kb on sensors using only milliwatts – solar and battery powered
- Low power wireless connectivity such as LoRA and 5G Redcap are enabling far-flung deployments
- Generative AI models (and/or "Extractive AI") coming to the edge – Meta's LLAMA model shrank 10x in 9 months – for rich sensor descriptions and enhanced telemetry
- "Observational learning" is enabling robotics platforms on the edge with Generative AI

"up to 99% of use cases could be addressed using SLMs . . 2024 will be the year of the SLM."
– CEO of Hugging Face

A Broad Community of Expertise

- Community of R&D/academia
- Coursework/training for classes
- Access to technology companies for platforms, tools
- Opportunities for mentorship, internship, career paths
- AI for Good volunteering

- Knowledge of state-of the-art
- Partnership and Business Development opps
- Exposure to ecosystem/solutions
- Access to talent
- Responsible AI guidelines/navigation

- Access to leading edge tech
- Exposure to tech suppliers
- Access to commercial customers
- Access to talent
- Responsible guidelines / navigation

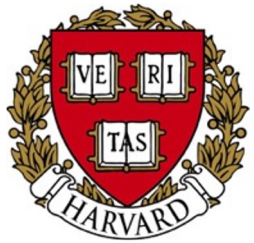
- Access to leading edge tech/knowledge
- Access to voice of the customer
- Feedback and input on legislation on behalf of industry

- Provide voice of the customer
- Access to leading edge tech/knowledge
- Provide AI for Good opportunities
- Find solutions with partners
- Access to talent
- Responsible guidelines / navigation

Bridging the Academic and Professional Communities

The Abdus Salam International Centre for Theoretical Physics

- tinyML EDU efforts have educated over 100k students worldwide
- tinyML Foundation Symposiums highlight academic research alongside industry events
- Support scholarships for next gen AI leadership
- Opportunities for mentorships, internships and talent pipelines
- Starting IAB (Industry-Academic Board)

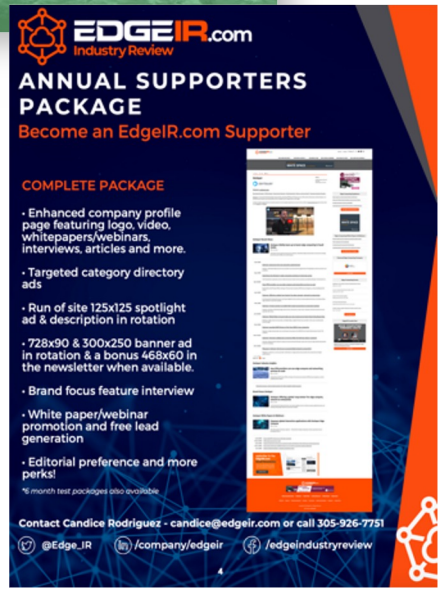


JOHNS HOPKINS UNIVERSITY

Scholarship Partner Program

- Provide qualified **value-added services** to the tinyML Foundation Community
- Enable **“most favored nation” pricing** to tinyML Foundation Partners
- Drive a virtuous circle with funding for the **Academic Scholarship program**

- First two partners - **5V** and **EDGEIR**



Navigating Responsible AI and AI for Good Engagements for our Community

- Member of the ITU AI for Good effort
  - tinyML Workshop at the 2024 Summit in Geneva
- World Economic Forum member
  - Developing best practices across industries, educating policy makers
  - Member, AI Governance Council
- Sponsoring Hackathons tackling societal challenges
  - 2023 Pedestrian Safety Hackathon with Infineon, Sony and Brainchip

Strengthening Community with In-Person Events

"It is my first time attending the tinyML Summit, and the experience has been fantastic. I had the opportunity to network with top edge ML researchers from both industry and academia, discussing the current and future challenges of implementing ML on low-power devices…"

– Wilfredo Lugo-Beauchamp,
Assistant Professor, University of Puerto Rico

tinyML Foundation Milan – June 2024

*“The forum was not just about sharing knowledge but also about absorbing the creative energy from many friends and colleagues I met for the first time. The future of innovation is bright, and it's built on the **dense layers of human connections** we make…”*

– Nabarun Dasgupta, ST Microelectronics

Sample Topics Addressed by the Community

Symposiums

Online and in-person, presentations and panels with industry and academic researchers that dig into what's next with Edge AI

- AI/ML for Embodied Systems at the Edge: Generative Models, LLMs and Beyond
- Transformer-Based Model Deployment on Edge Devices through MicroNPUs Operator Converter
- On-device Contextual AI: Challenges and Opportunities
- AI models for Medical Devices
- Inspired by 'Her': AI interaction models we'd like to see
- High Efficiency Computer Vision
- Ultra-Efficient On-Device Object Detection on AI-Integrated Smart Glasses
- Tiny Graph Neural Networks for Radio Resource Management
- Comparing Classic Machine Learning Techniques with Deep Learning for TinyML Human Activity Recognition
- Simulating Battery-Powered TinyML Systems Optimized using Reinforcement Learning in Image-Based Anomaly Detection
- SpokeN-100: A Cross-Lingual Benchmarking Dataset for the Classification of Spoken Numbers in Different Languages

RECENT EVENTS

Asia 2023
(Seoul)

Predictive Maintenance & Anomaly Detection

Summit 2024
(Silicon Valley)

GenAI on the Edge

EMEA 2024
(Milan)

Partnership Value

Technology Providers

Understand state-of-the-art, develop cutting-edge partnerships, engage with customers and solution providers, marketing value

Commercial Customers

Discover solution and technology partners, Edge AI technology trends, talent pipeline

Academic Institutions

Collaboration on AI R&D, mentorship/ internship opps for students in technology industry

We are on a mission. . .

- Thought leadership
- Accelerating partnerships
- Voice of the Customer
- Cultivate next-gen leadership

High bandwidth business results

- Regional Community Events
- Working groups
- Partnerships
- Hackathons for Industry Verticals
- Knowledge Certification programs

Accelerate academia

- Symposiums to highlight cutting edge research
- Scholarships and funding
- Talent pipelines, and mentorship/internship programs

Societal impact

AI for Good via United Nations and World Economic Forum ++

Responsible AI thru policymaker education

Security/transparency working groups

Hackathons for societal solutions

Make Edge AI a Digital AND a Societal Transformation

tinyML Foundation support and organization

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Pete Bernard, Executive Director

- EDGECELSIOR - Founder & Principal
- Microsoft - 18 years
  - Senior Director - Azure Edge HW/5G
  - Principal Group Program Manager - WDG Product Engineering
- Silicon Valley - 14 years
  - Insignia Solutions - Chief Product Officer
  - E Color - VP Products
  - Phoenix Technologies - Dr. of Technology
- BS Computer Engineering - Boston University

Join Growing tinyML Communities:

The tinyML Community

https://www.linkedin.com/groups/13694488/

The tinyML Channel

https://www.youtube.com/tinyML