

Scaling TinyML



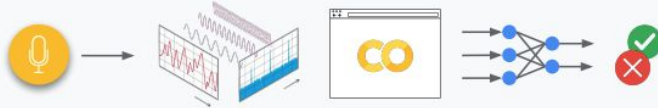


Fundamentals of *TinyML*

Loss Function Filters Data augmentation
Classification Gradient Descent Regression
Preprocessing Responsible AI Inference
Neural Network Validation data

Course 1

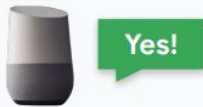
Applications of *TinyML*



Course 2

Deploying *TinyML*

Keyword Spotting



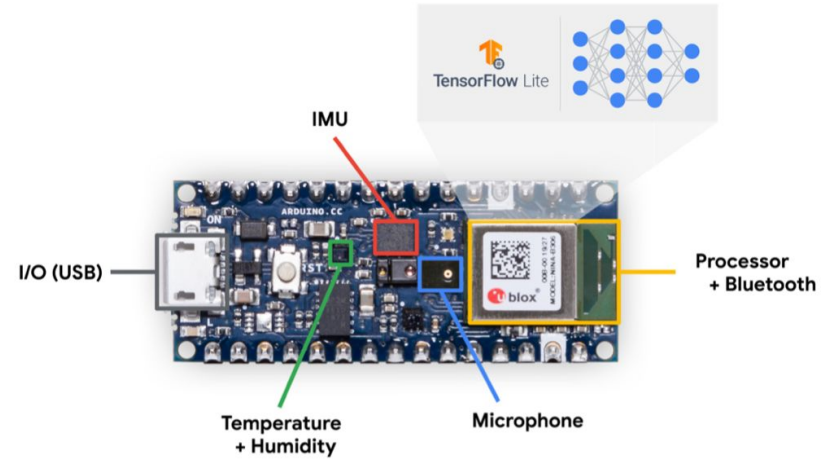
Visual Wake Words

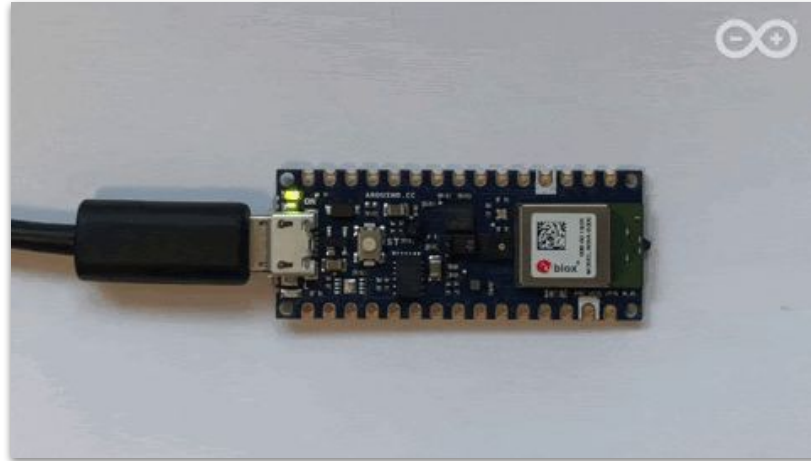


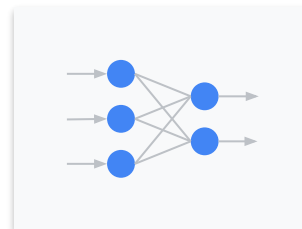
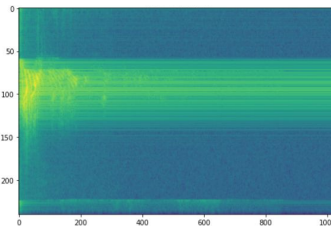
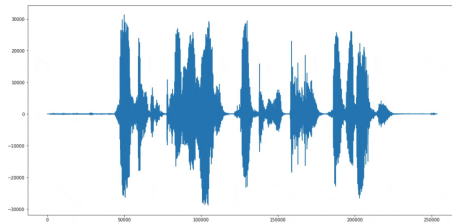
Gesture Recognition



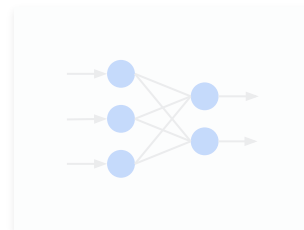
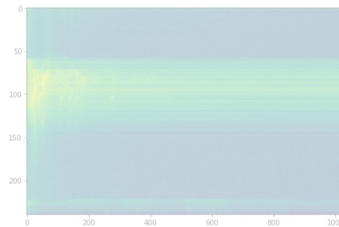
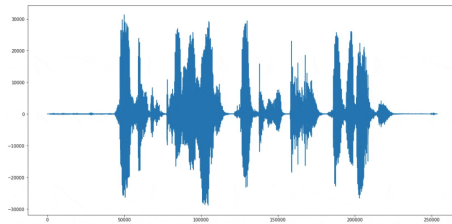
Course 3



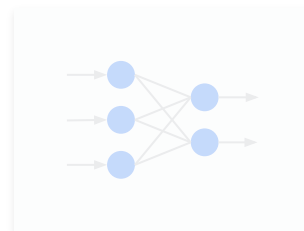
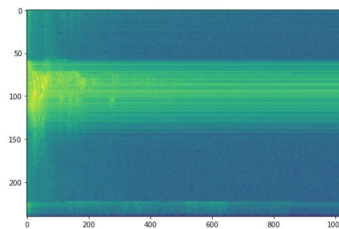
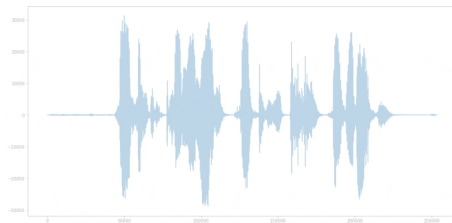




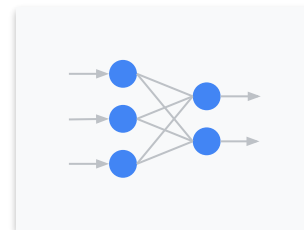
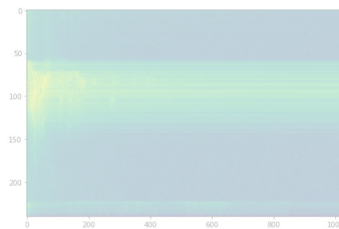
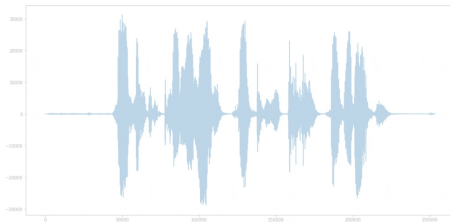
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“No” - 0.09



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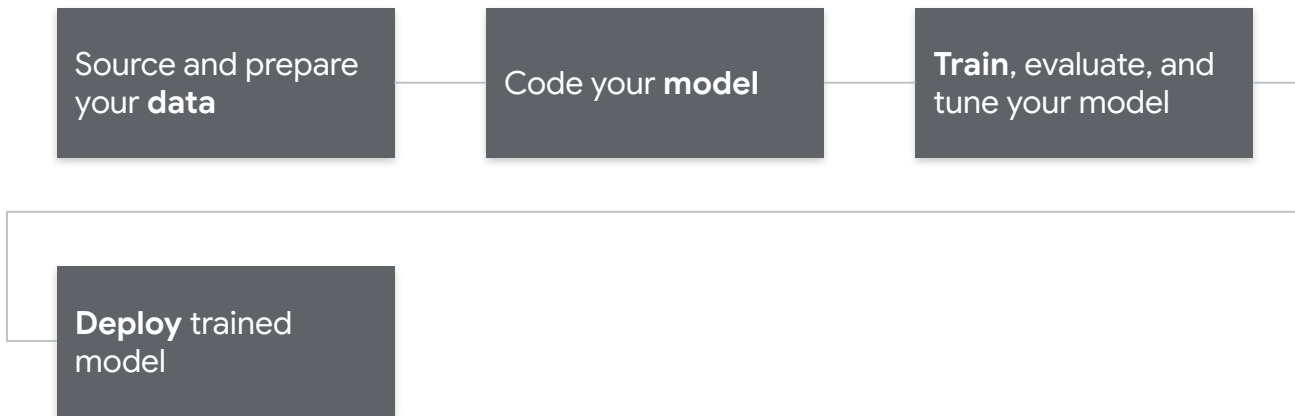


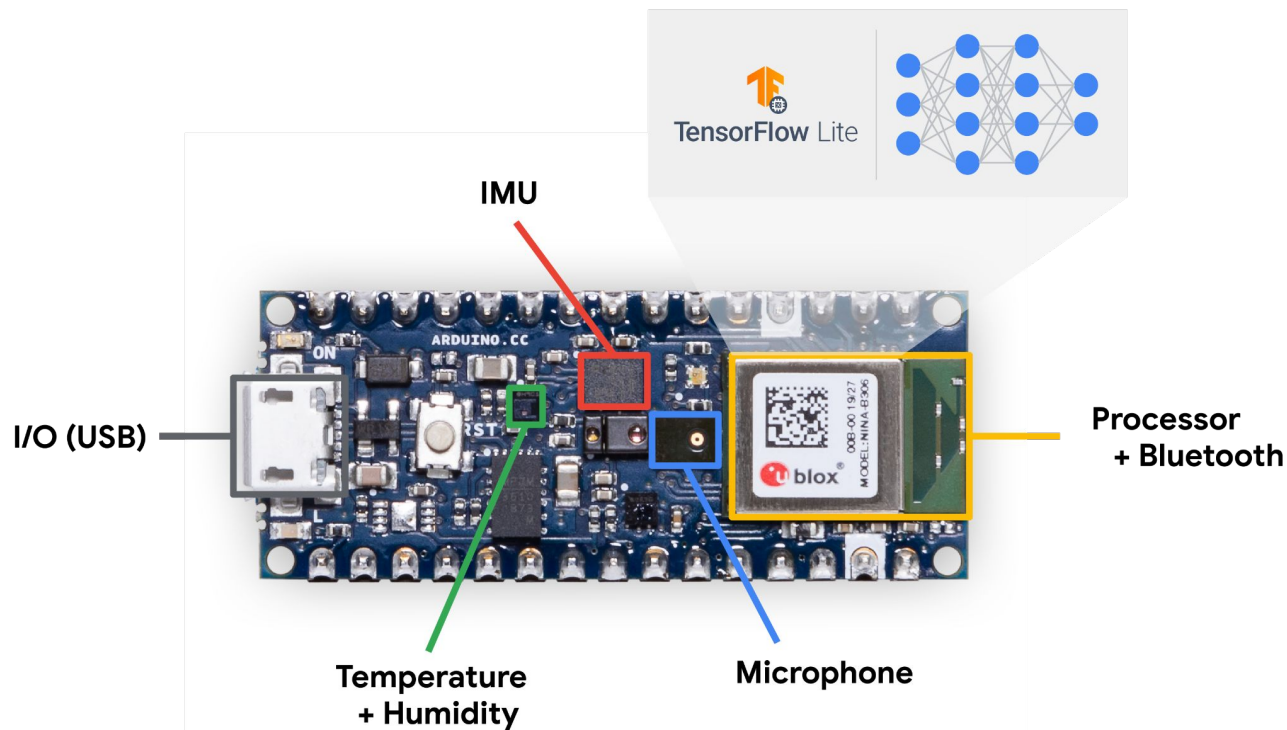
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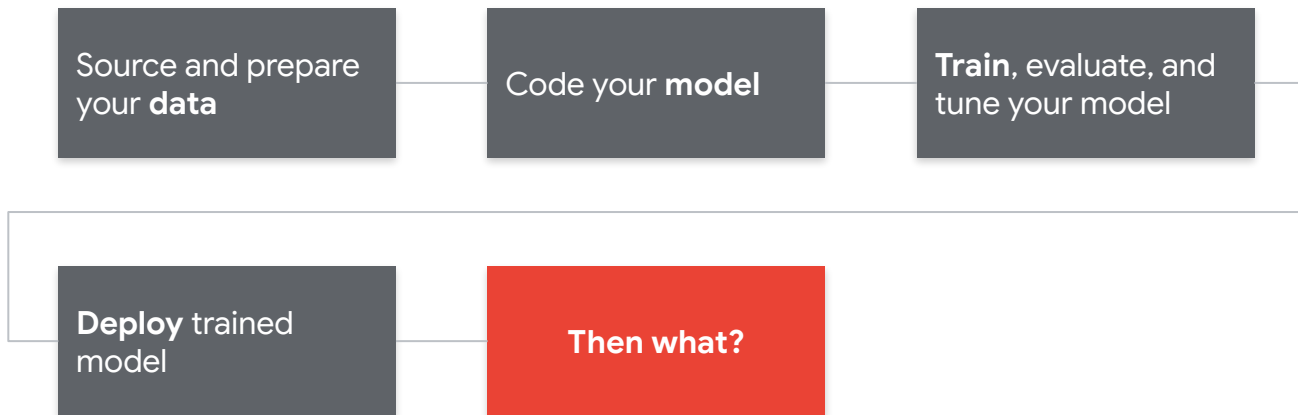
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The Machine Learning Workflow

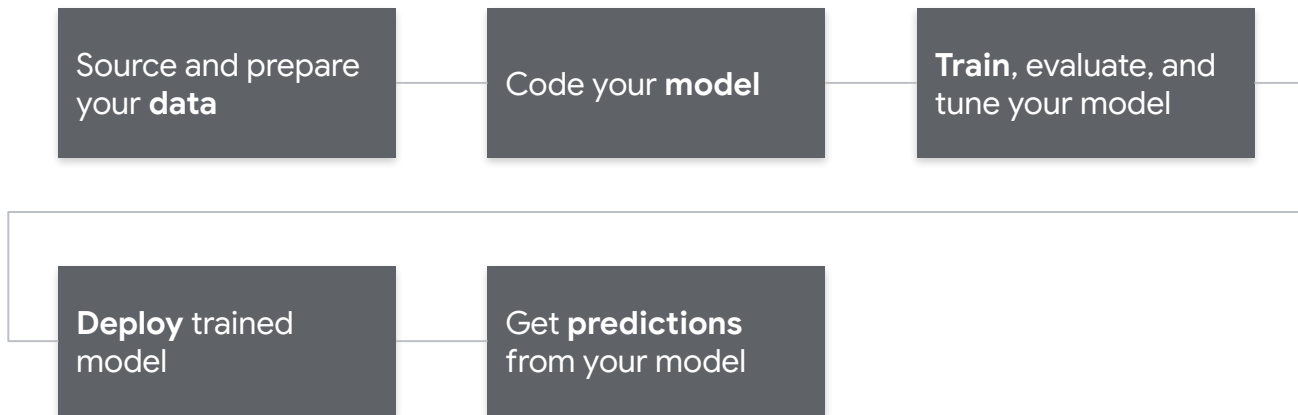




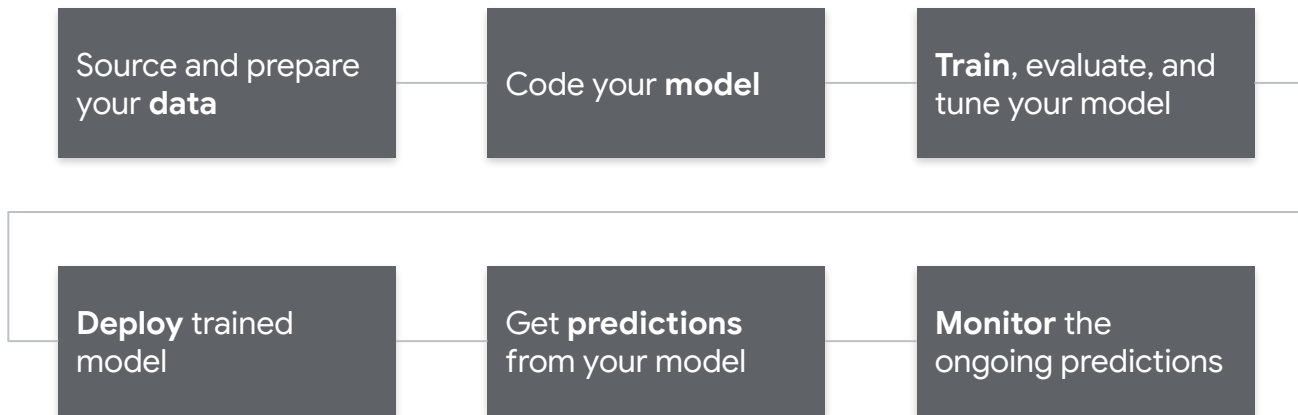
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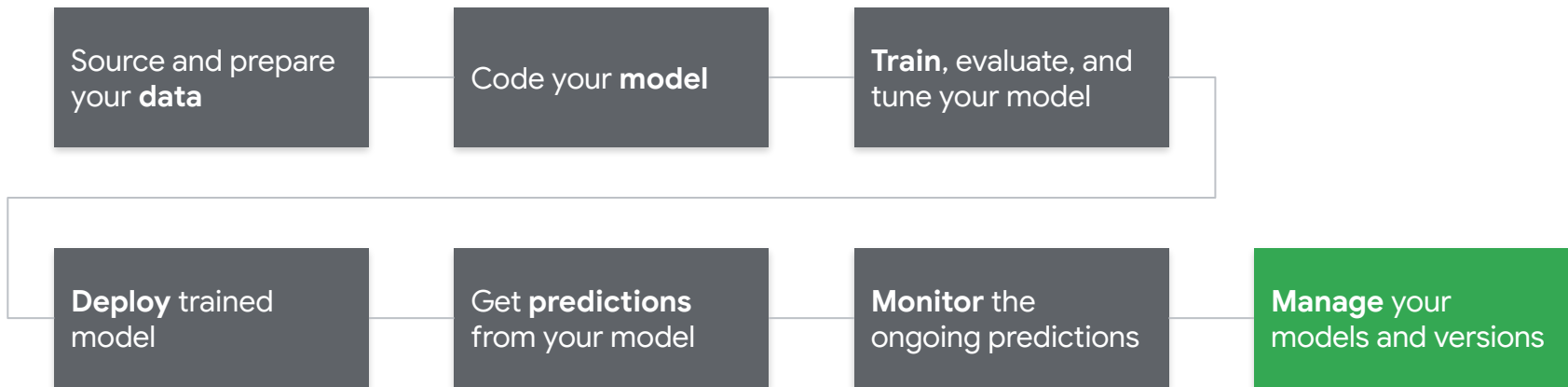
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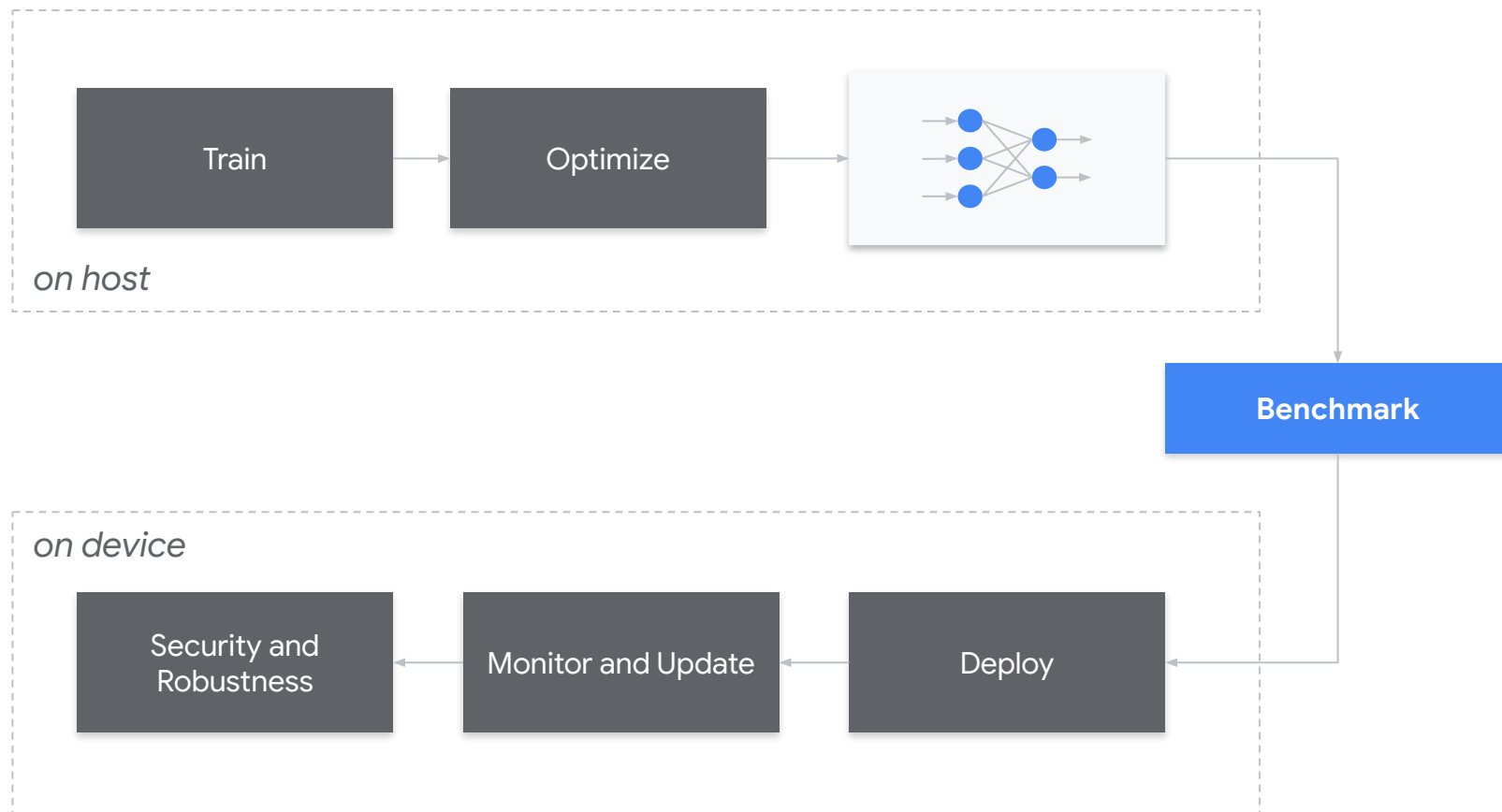


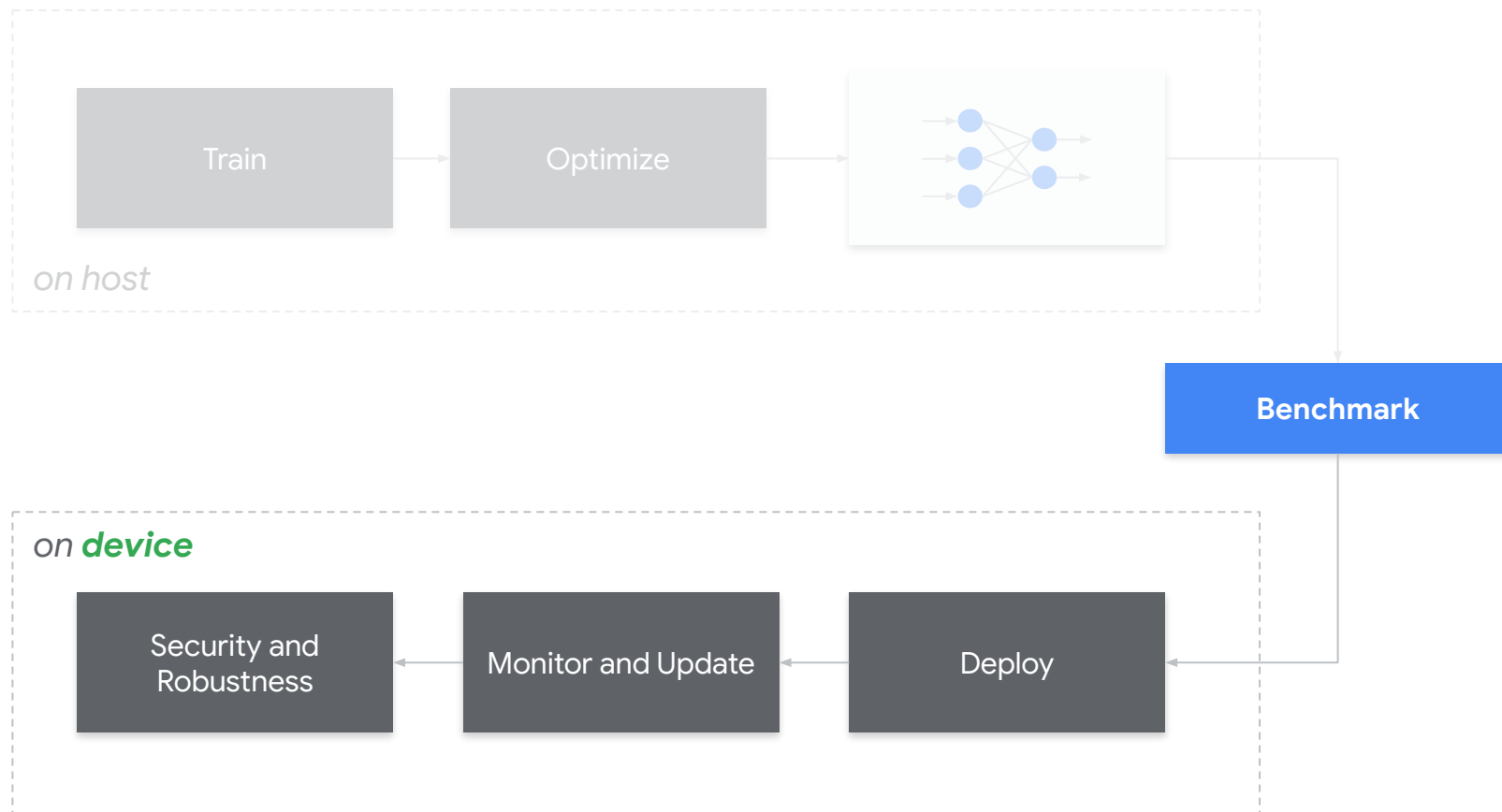
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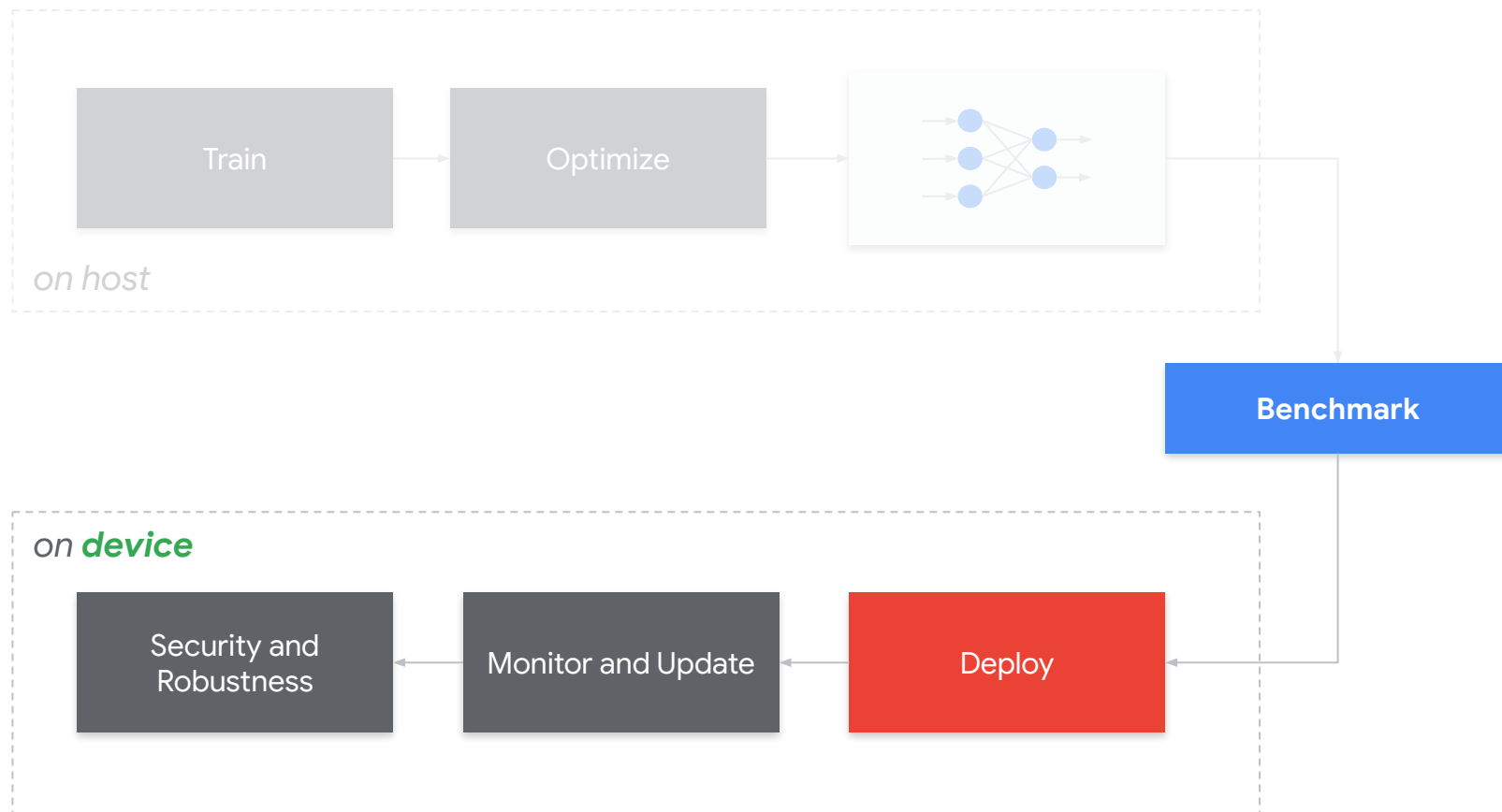


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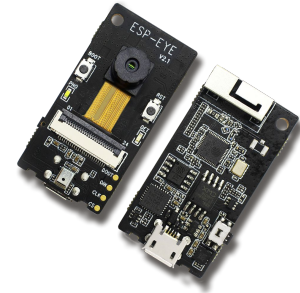
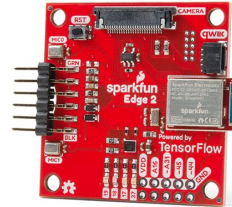
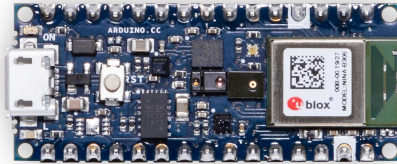








Embedded Systems







Deployment Challenges







Board	MCU / ASIC	Clock	Memory	Sensors	Radio
Himax WE-I Plus EVB	HX6537-A 32-bit EM9D DSP	400 MHz	2MB flash 2MB RAM	Accelerometer, Mic, Camera	None
Arduino Nano 33 BLE Sense	32-bit nRF52840	64 MHz	1MB flash 256kB RAM	Mic, IMU, Temp, Humidity, Gesture, Pressure, Proximity, Brightness, Color	BLE
SparkFun Edge 2	32-bit ArtemisV1	48 MHz	1MB flash 384kB RAM	Accelerometer, Mic, Camera	BLE
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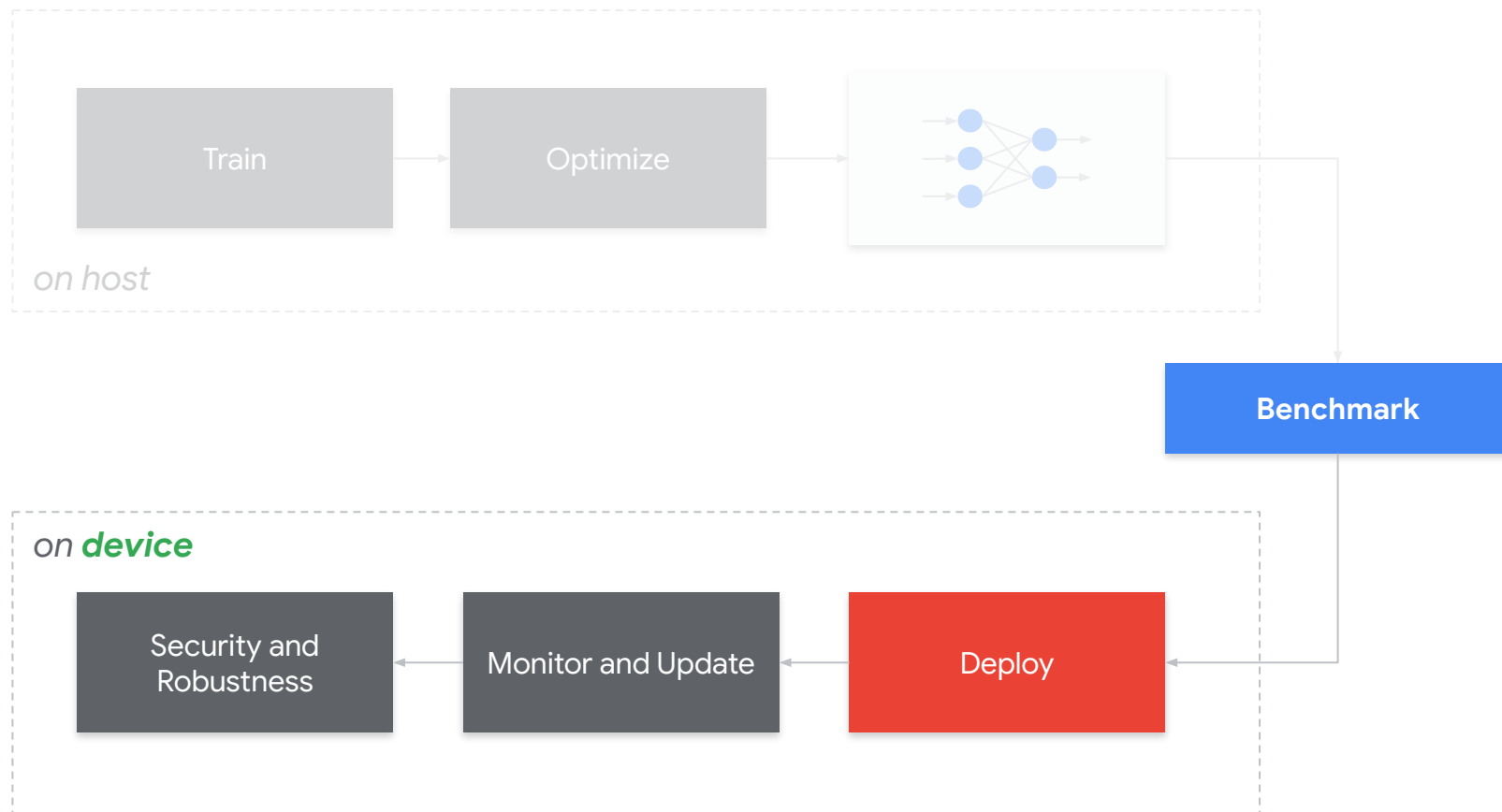
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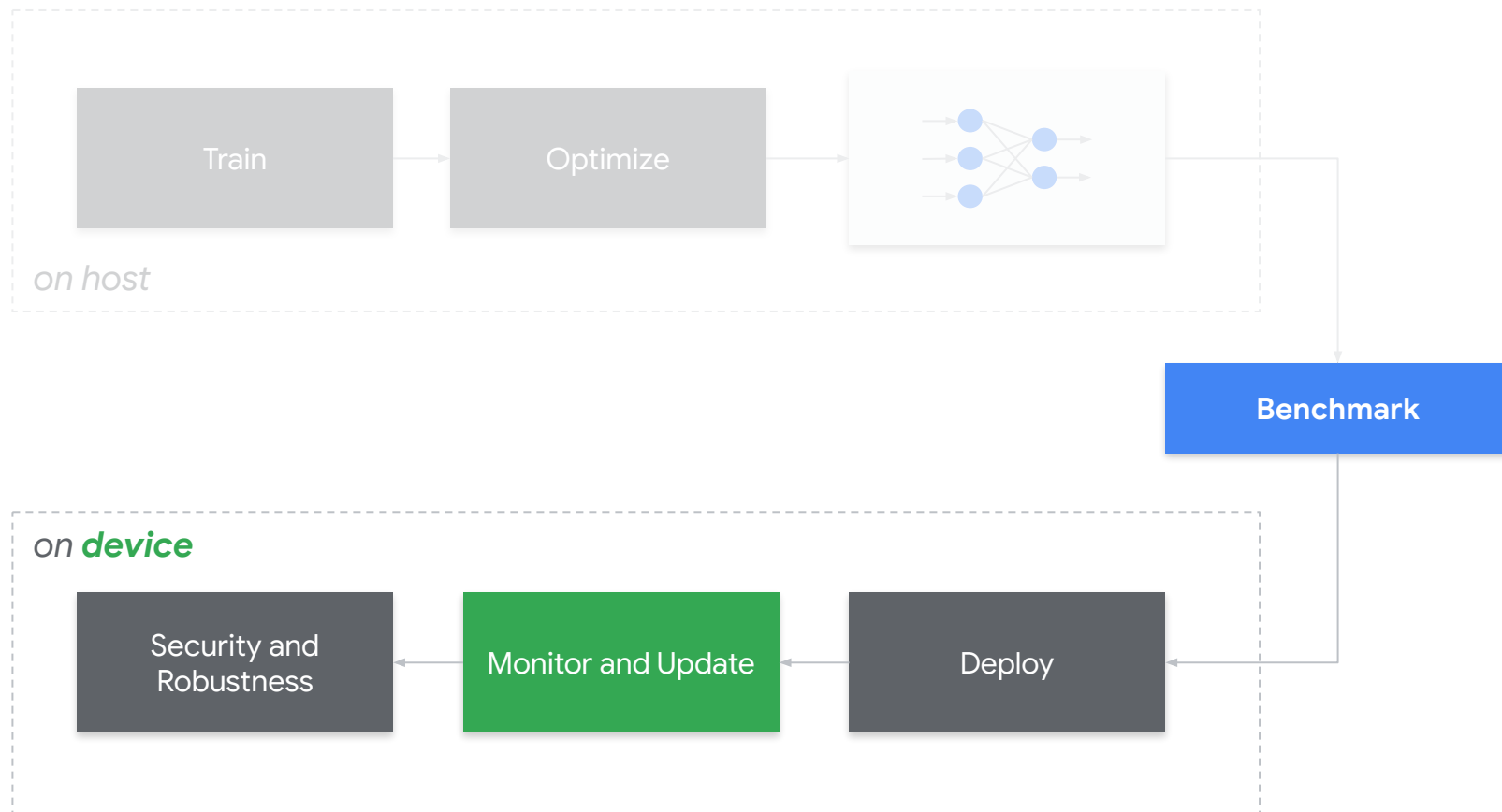
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

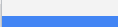
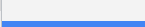
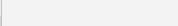

Monitoring Challenges

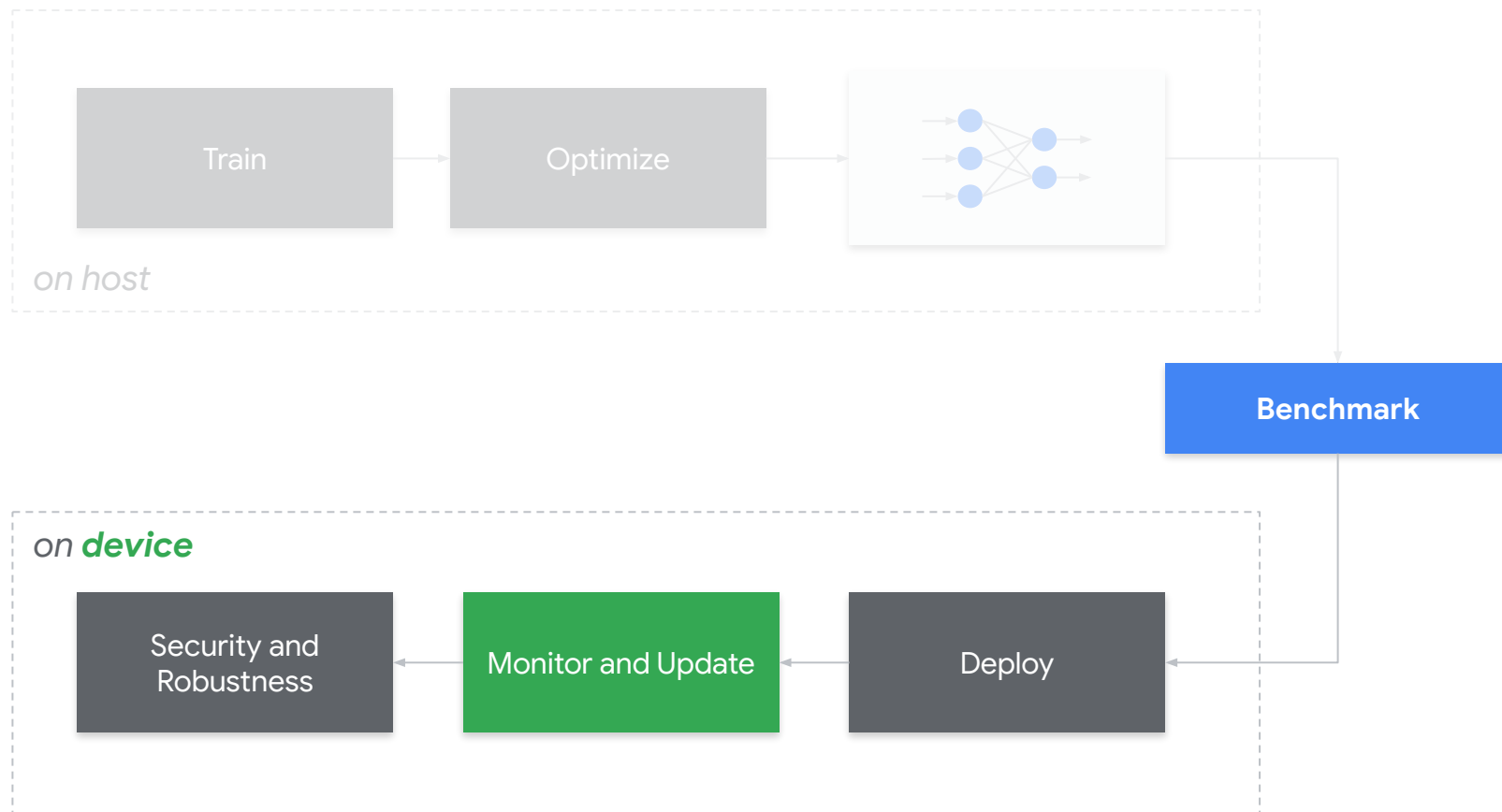


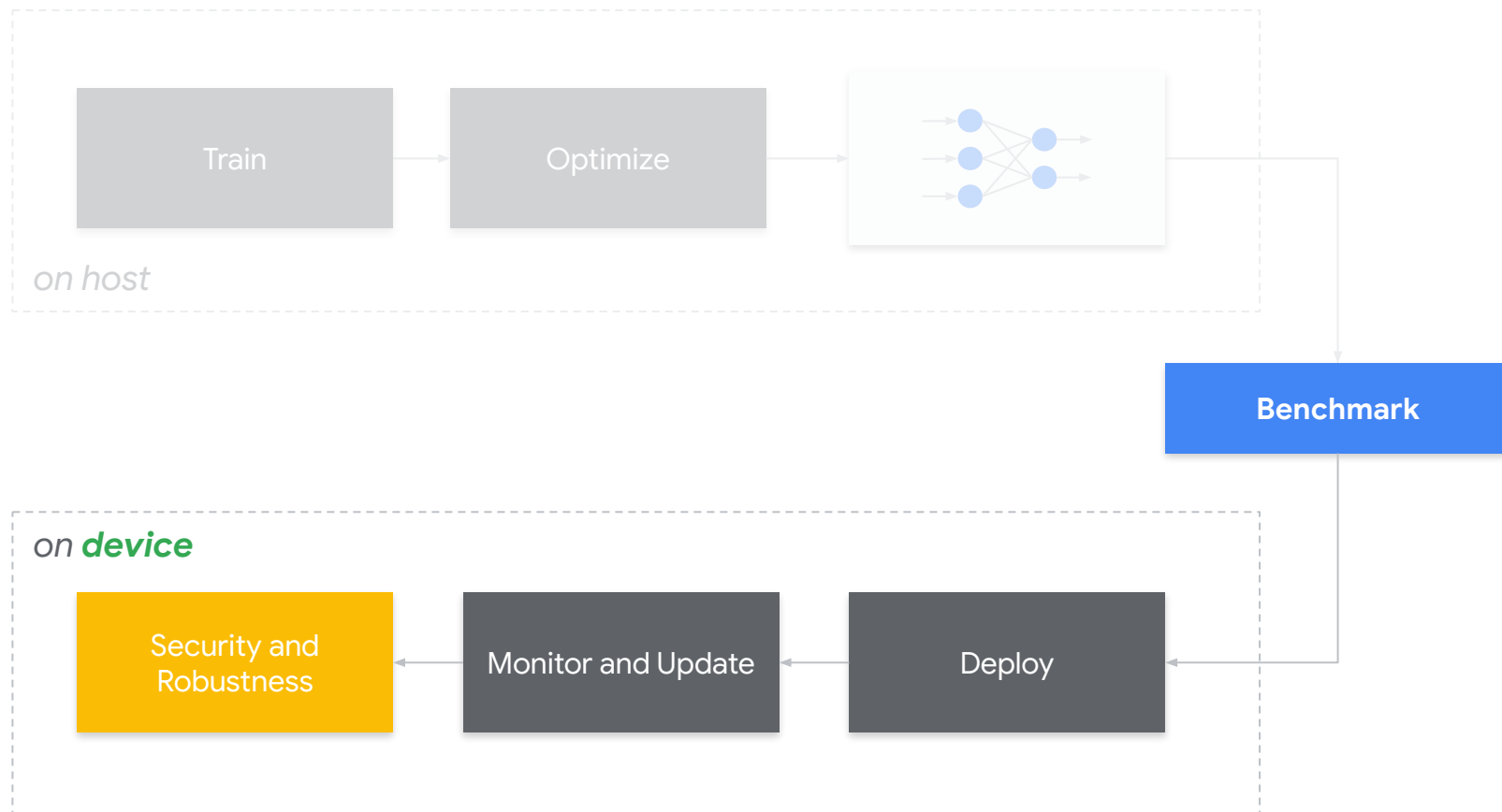
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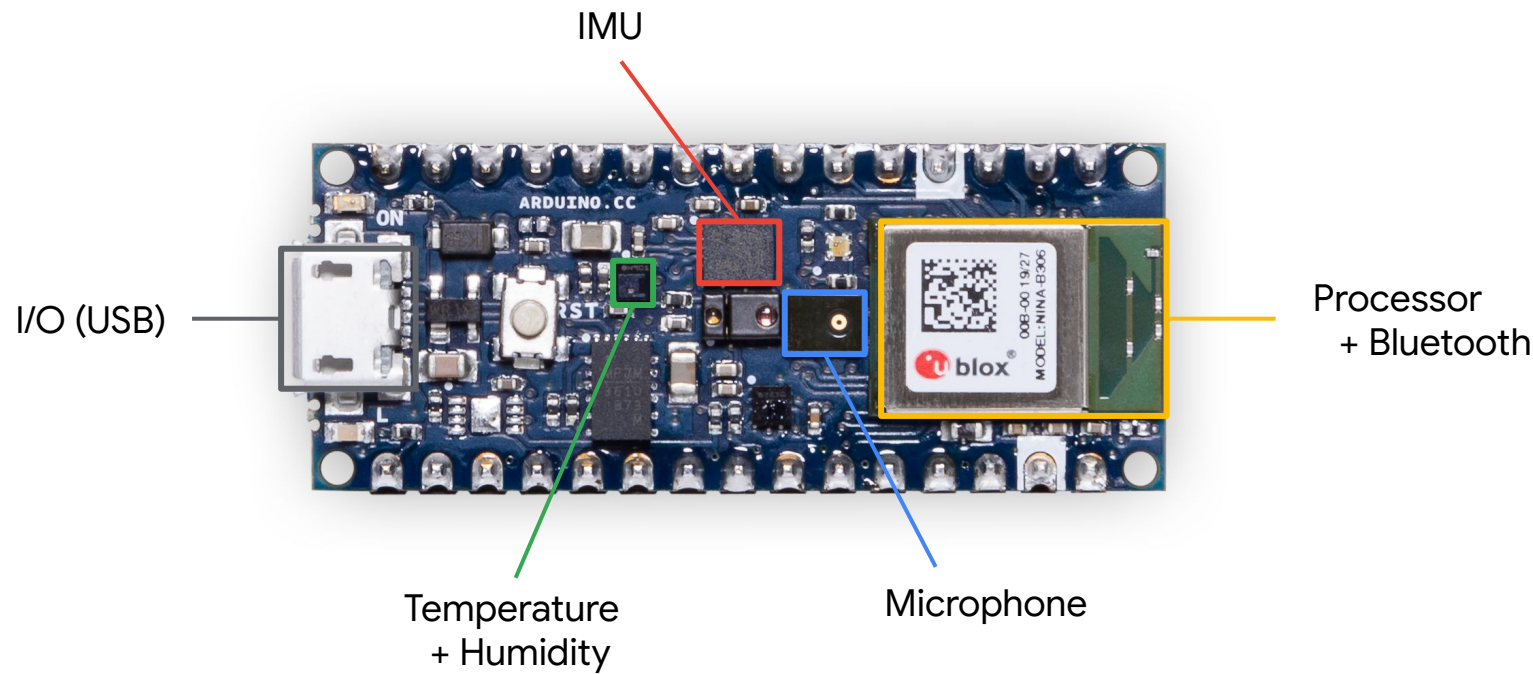
Compute v. Communication

- Compute is **cheap** and consumes relatively little power compared to moving data
- Communication is all about **moving data (\$)**





Operation	Energy (pJ)	Relative Energy Cost
8b Add	0.03	
32b Add	0.1	
32b FP Add	0.9	
8b Multiply	0.2	
32b Multiply	3.1	
32b FP Multiply	3.7	
32b SRAM Read (8KB)	5	
32b DRAM Read	640	







Security & Robustness Challenges

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