



BeatCraft, Inc. since 2000.05.17

Masashi Takemoto, Ph.D.  
lesser@beatcraft.com



# About BeatCraft, Inc

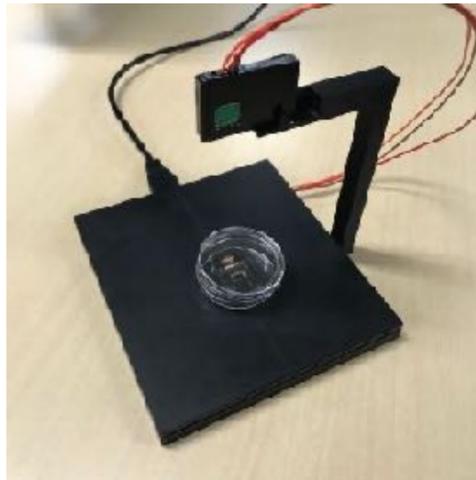
- Core Technologies
  - Embedded Systems / IoT
  - AI (Deep Learning)
  - Wireless Communication (BLE and 11ah)
  - Digital Holography (Lens-Free Imager)
- Fields
  - Agriculture
  - Bio / Medical
  - Industrial Equipments

BC is a R&D company, and provides technologies to partners.

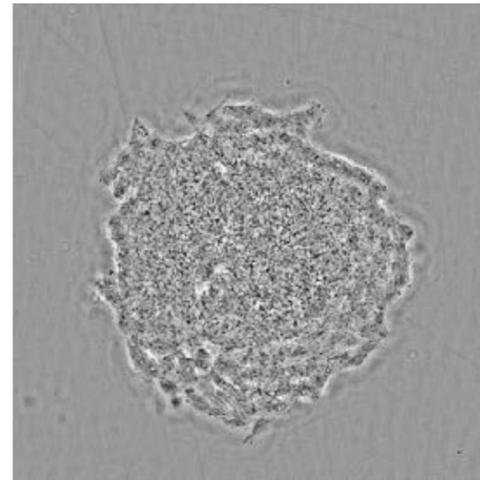
# Lens-free Imager

New microscopy technology for cell inspections

Proto-Type



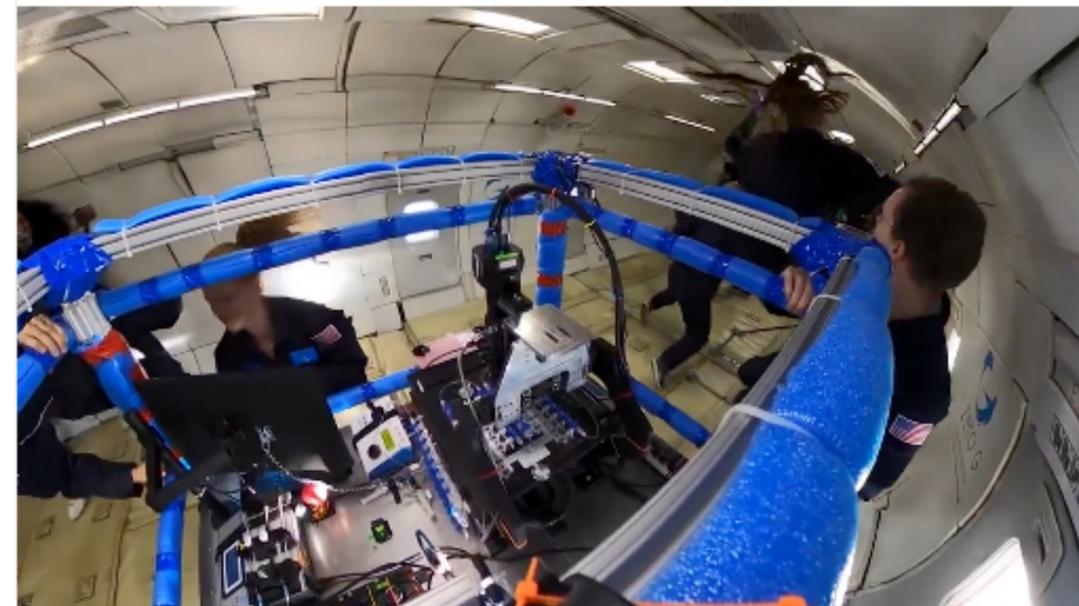
IPS cell colony



Collaboration with Tokyo University Agriculture and Technology and IMEC



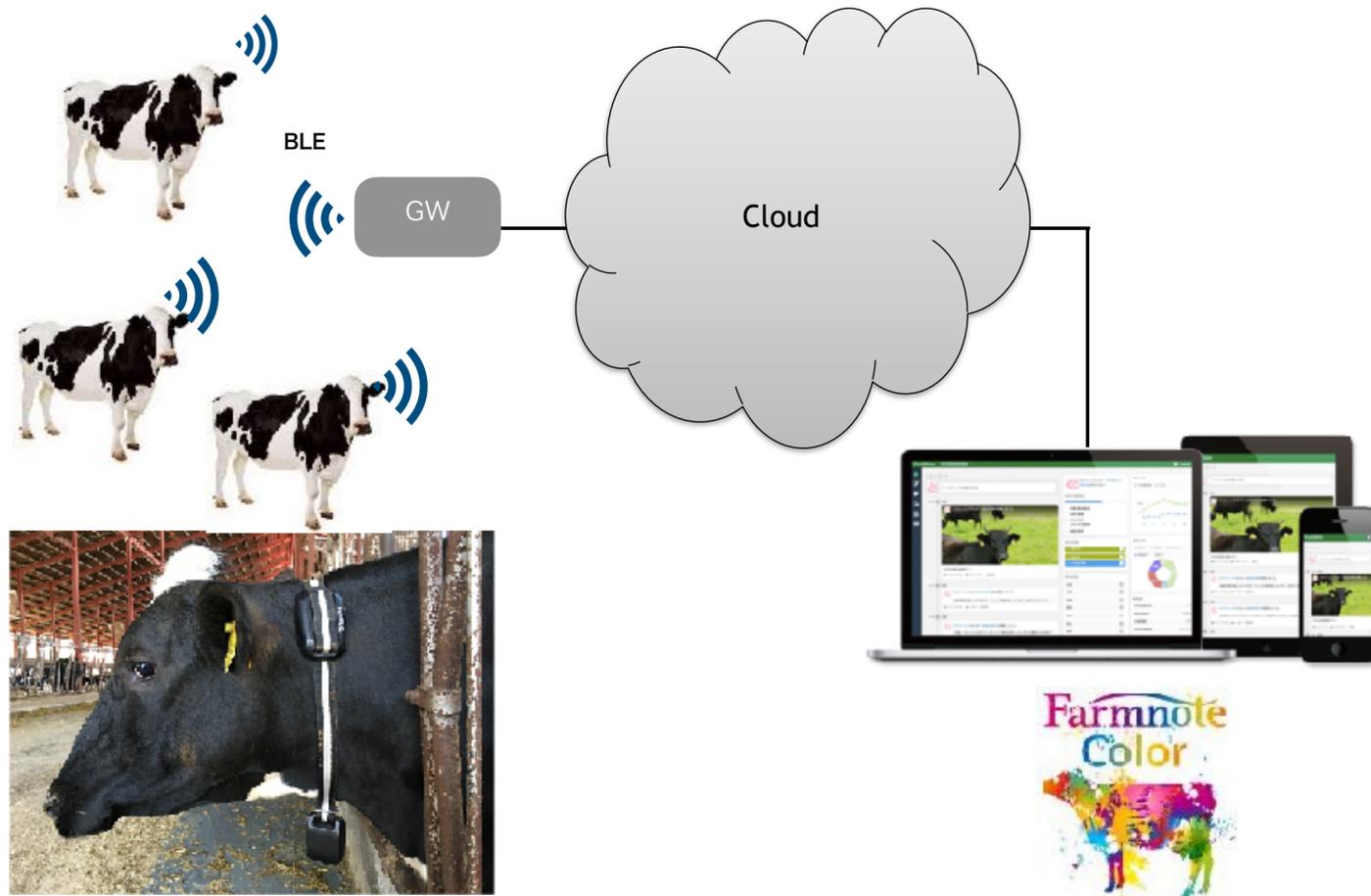
## Blood inspection under zero-G



# IoT System for a cow

2020.01.08

The system optimizes milk production by predicting cow's estrus from its activities sensed by an accelerometer.



## The 8th Monozukuri Nippon Grand Award Prime Minister's Prize Winner





## Implementation of DNN on a RISC-V Open Source Microprocessor for IoT devices

- October 2018
- DOI: 10.1109/GCCE.2018.8574663
- Conference: 2018 IEEE 7th Global Conference on Consumer Electronics (GCCE)
- Jingyong Cai, Masashi Takemoto, Hironori Nakajo

Existing techniques such as Logarithmic Quantization and feature extraction enable us to reduce model parameters to a great extent. Based on these methods, we have implemented a small sized DNN on a RISC-V microprocessor with RAM of only 16KB. We also propose a feature extraction algorithm combined with neural network outperforming the plain original neural network. MNIST dataset is used as our training samples and Chainer is used to train the network. As the result, we reduced weights size by nearly 86 from 49.625KB to 0.578KB which make it possible to store these weights in arrays and load them directly into the tiny RAM.

## A Deep Look into Logarithmic Quantization of Model Parameters in Neural Networks

- December 2018
- DOI: 10.1145/3291280.3291800
- Conference: the 10th International Conference
- Jingyong Cai, Masashi Takemoto, Hironori Nakajo

Based on the fact that parameters of pre-trained neural networks naturally have non-uniform distributions, logarithmic quantization of network parameters achieves better classification results than linear quantization of the same resolution. In our practice, we found that the logarithmic quantization suffers huge accuracy decrease on small size neural networks. This is because the parameters of trained small neural networks are not highly concentrated around 0. In this paper, we analyse in depth the attributes of logarithmic quantization. In addition, existing compression algorithms highly rely on retraining which requires heavy computational power. In such a situation, we propose a new logarithmic quantization algorithm to mitigate the deterioration on neural networks which contain layers of small size. As the result, our method achieves the minimum accuracy loss on GoogLeNet after direct quantization compared to quantized counterparts.

## Trigonometric Inference Providing Learning in Deep Neural

- July 2021
- DOI: 10.3390/app11156704
- Applied Sciences
- Jingyong Cai, Masashi Takemoto, Yuming Qui, Hironori Nakajo

Despite being heavily used in the training of deep neural networks (DNNs), multipliers are resource-intensive and insufficient in many different scenarios. Previous discoveries have revealed the superiority when activation functions, such as the sigmoid, are calculated by shift-and-add operations, although they fail to remove multiplications in training altogether. In this paper, we propose an innovative approach that can convert all multiplications in the forward and backward inferences of DNNs into shift-and-add operations. Because the model parameters and backpropagated errors of a large DNN model are typically clustered around zero, these values can be approximated by their sine values. Multiplications between the weights and error signals are transferred to multiplications of their sine values, which are replaceable with simpler operations with the help of the product to sum formula. In addition, a rectified sine activation function is utilized for further converting layer inputs into sine values. In this way, the original multiplication-intensive operations can be computed through simple add-and-shift operations. This trigonometric approximation method provides an efficient training and inference alternative for devices with insufficient hardware multipliers. Experimental results demonstrate that this method is able to obtain a performance close to that of classical training algorithms. The approach we propose sheds new light on future hardware customization research for machine learning.



# Learning Algorithm for LesserDNN, a DNN with Quantized Weights

In The 12th International Symposium on Information and Communication Technology (SOICT 2023), December 7–8, 2023, Ho Chi Minh, Vietnam. ACM, New York, NY, USA, 7 pages. <https://doi.org/10.1145/3628797.3628935>

## ABSTRACT

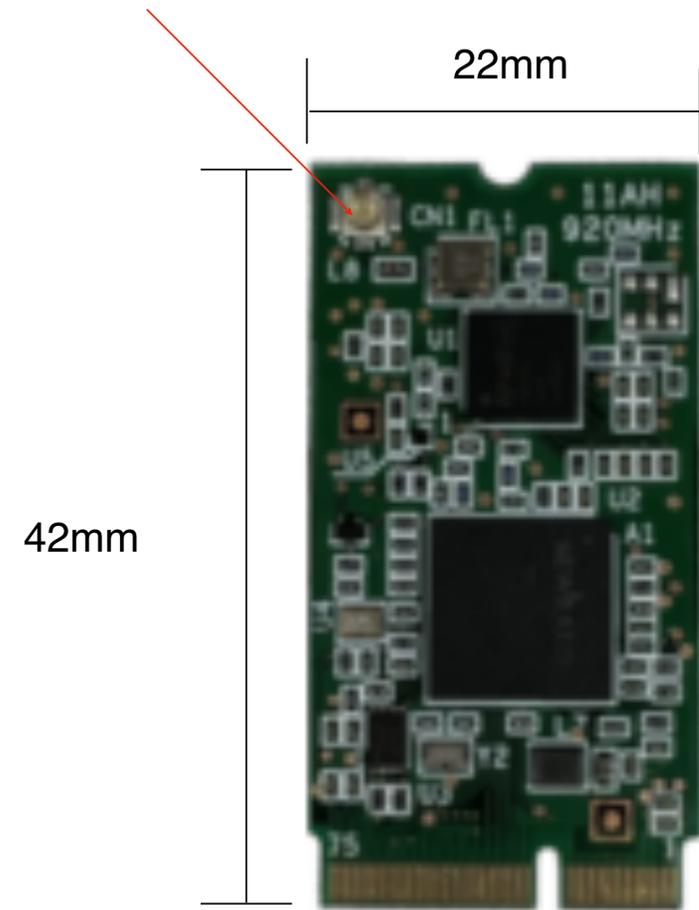
This paper presents LesserDNN, a model that uses a set of floatingpoint values  $\{-1.0, -0.5, -0.25, -0.125, -0.0625, 0.0625, 0.125, 0.25, 0.5, 1.0\}$  as quantized weights, and a new learning algorithm for the proposed model. In previous studies on deep neural networks (DNNs) with quantized weights, because DNNs employ the gradient descent method as their learning algorithm, quantized weights were applied only during the inference stage. Due to differentiability properties, quantized weights cannot be used when the gradient descent method is applied during training. To address this issue, we devised an algorithm based on simulated annealing. Since simulated annealing has no differentiability requirements, LesserDNN can utilize quantized weights during training. With the use of quantized weights and this simulated annealing-based algorithm, the learning process becomes a combinatorial problem. The proposed algorithm was applied to train networks on MNIST handwriting datasets. The tested models were trained with the simulated annealing-based algorithm and quantized weights, achieving the same level of accuracy as gradient descent-based comparison methods. Thus, LesserDNN has a simple design and small implementation scale because backpropagation is not applied. Moreover, this model achieves a high accuracy.



**BEST PAPER AWARD**

**Strategy : AI + 11ah → New market**

Antena Connector



22mm

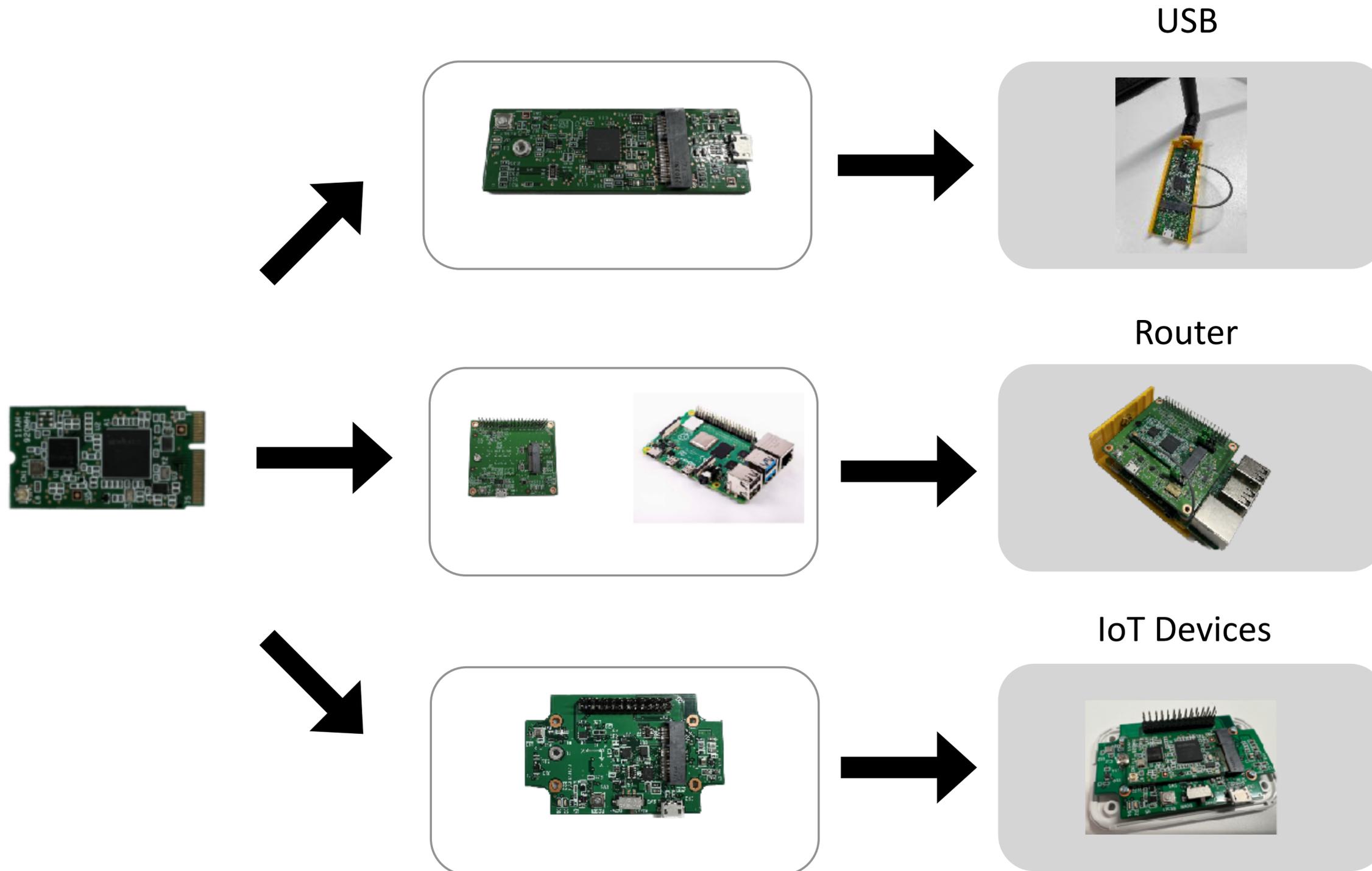
42mm

# BC-11ah

## IEEE802.11ah WiFi module

Approved by TELEC at May 22nd, 2023

M.2 Card Edge (75 pins)



**BC-11ah can be integrated into various forms.**

Temperature and humidity



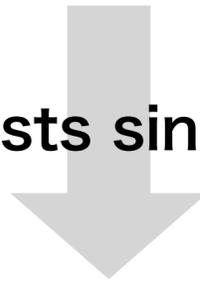
2K Still



Router



Field Tests since 2019



高知



木更津



岩見沢



**New partnership ?**

**PoC**

**Development**

**System designs and integrations**

**mass production**

Thank you.  
謝謝

