

## WHAT?

- ✓ LoRaWAN is widely deployed for IoT applications
- ✓ LoRa is physical layer standard for LoRaWAN
- ✓ Supports Long range over low power consumption
- ✓ LoRaWAN supports end-to-end encryption i.e **AES-128**
- ✓ LoRa end devices are still vulnerable to **IMPERSONATION!**
- ✓ **Requires additional layer of security at physical layer!**

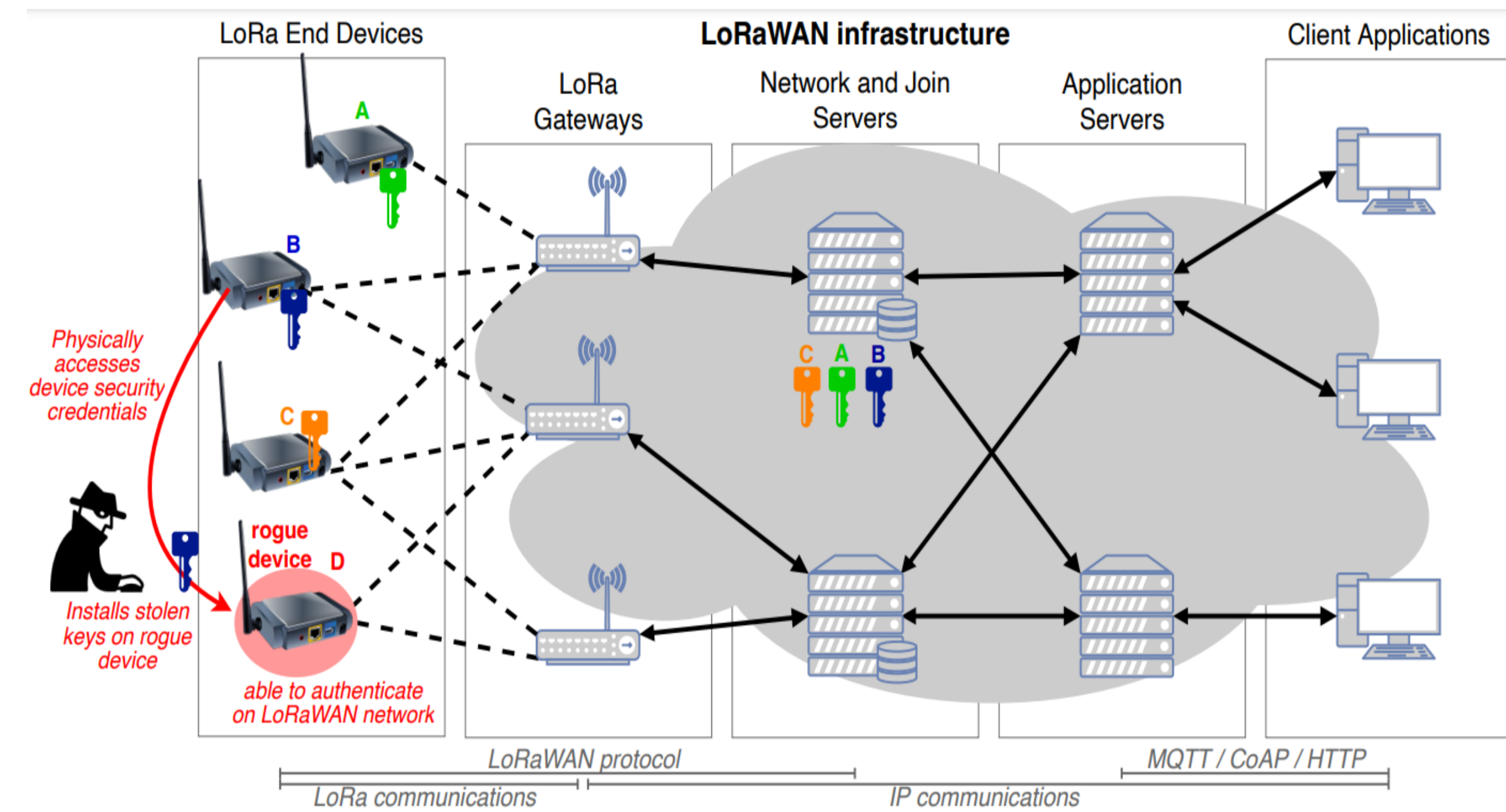


Fig 1: LoRaWAN impersonation scenario

## WHY?

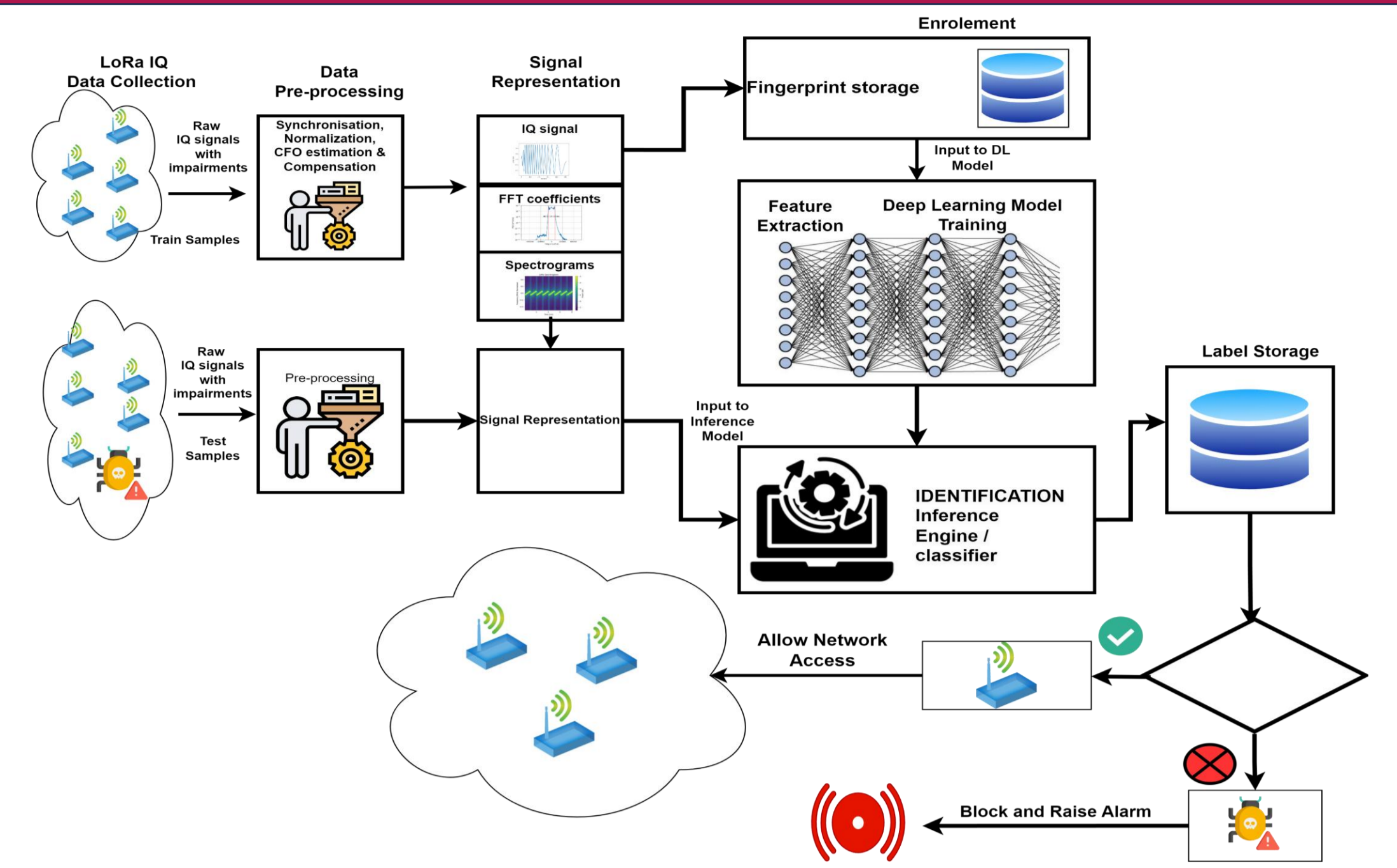


Fig 2: Deep learning based LoRa Radio Frequency Fingerprint Identification System (Classification with Rejection)

- ✓ Cryptography: **Hard on resources, vulnerable ...**
- ✓ Device RF Fingerprints: **Unique, hard to tamper**
- ✓ No **additional power requirements** at end device
- ✓ Deep Learning: proven performance at **automated feature extraction**
- ✓ DL based LoRa RFFI: Automated, feasible and affordable solution

## HOW?

### Data Collection and Signal Representation

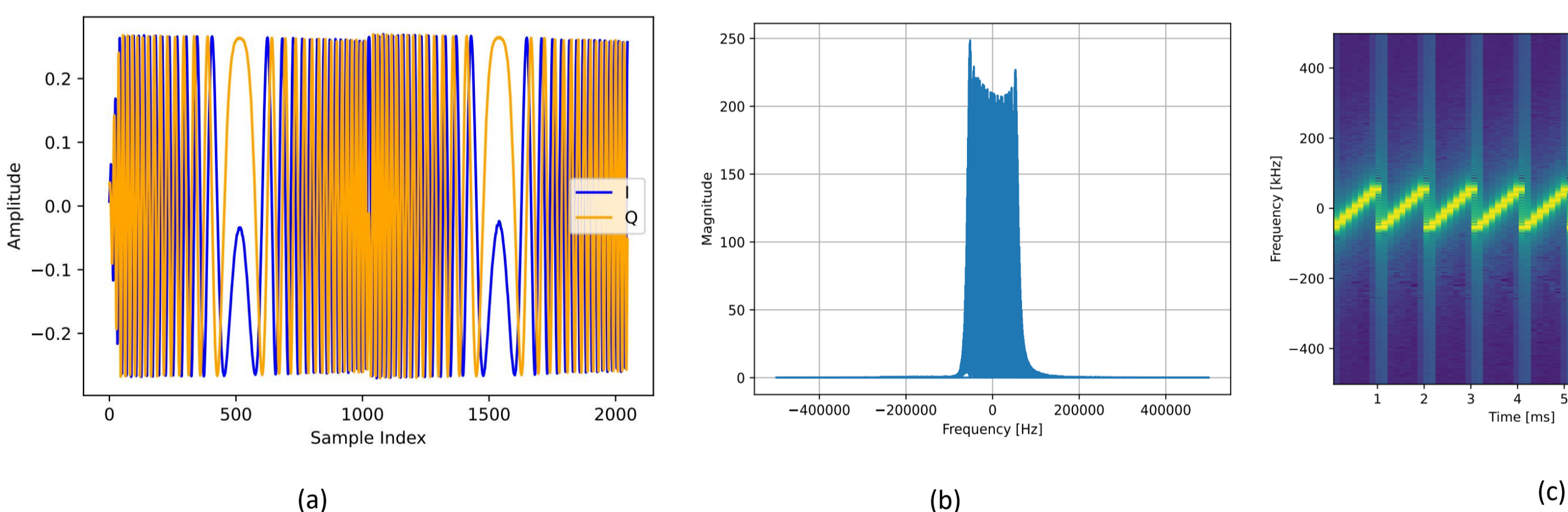
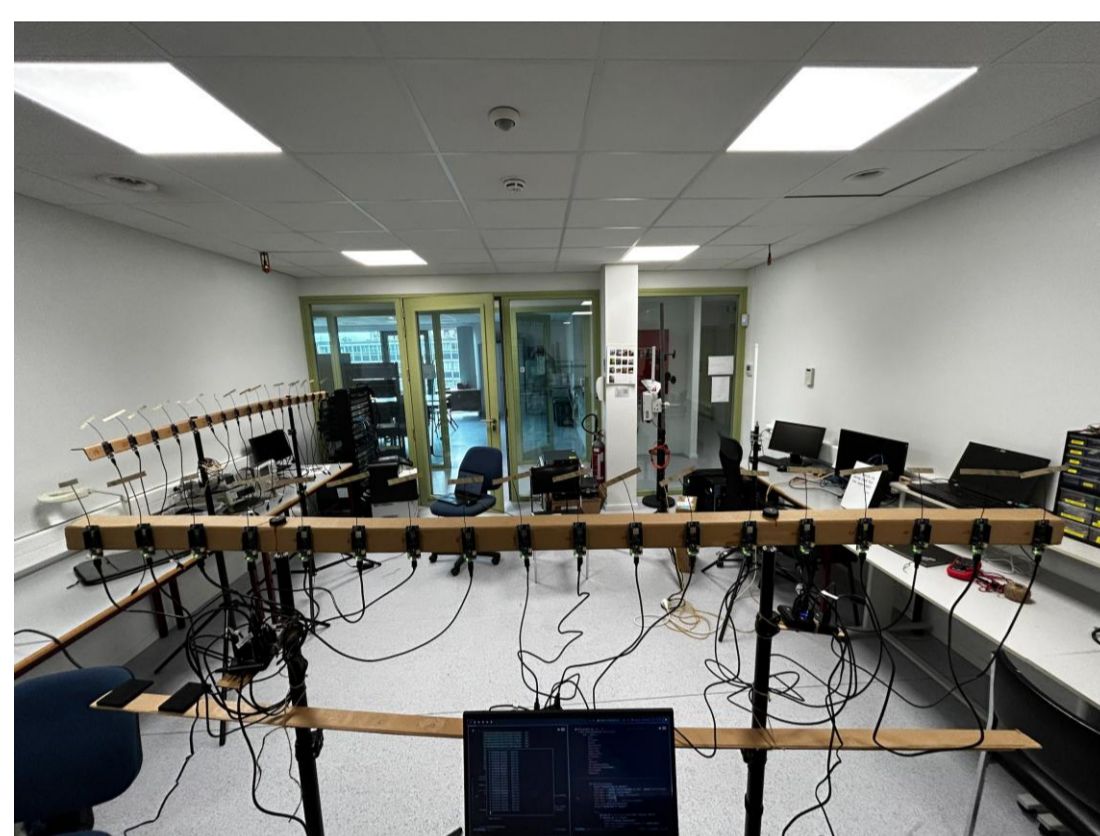


Fig 3: LoRa Signal Representation (a) Time domain IQ (b) FFT plot (c) Spectrogram

### DL Model Selection and Training

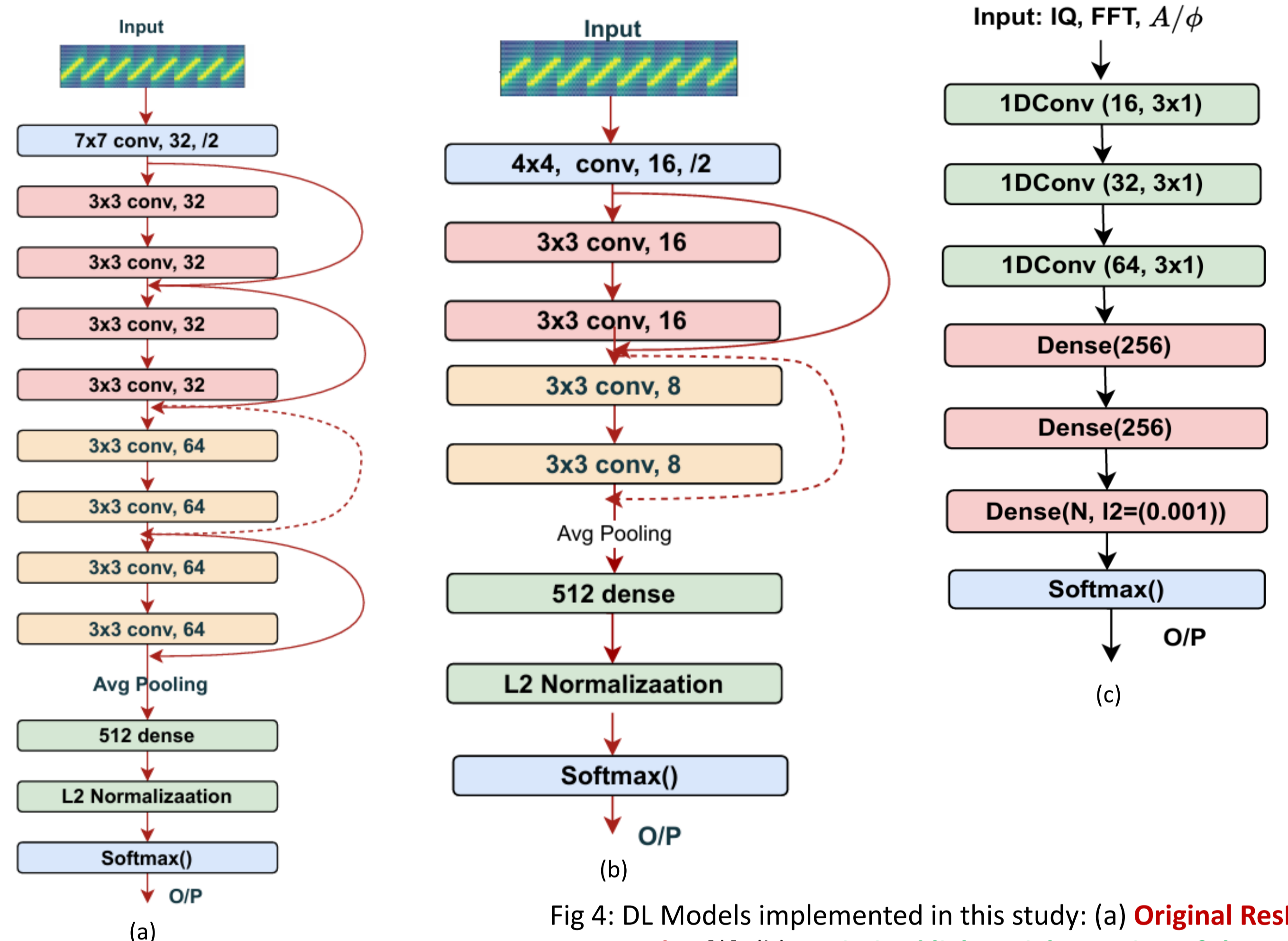


Fig 4: DL Models implemented in this study: (a) Original ResNet proposed in [\*,] (b) Optimized lightweight version of the original ResNet (c) Lightweight 1D-CNN model for sequential IQ data

## RESULTS

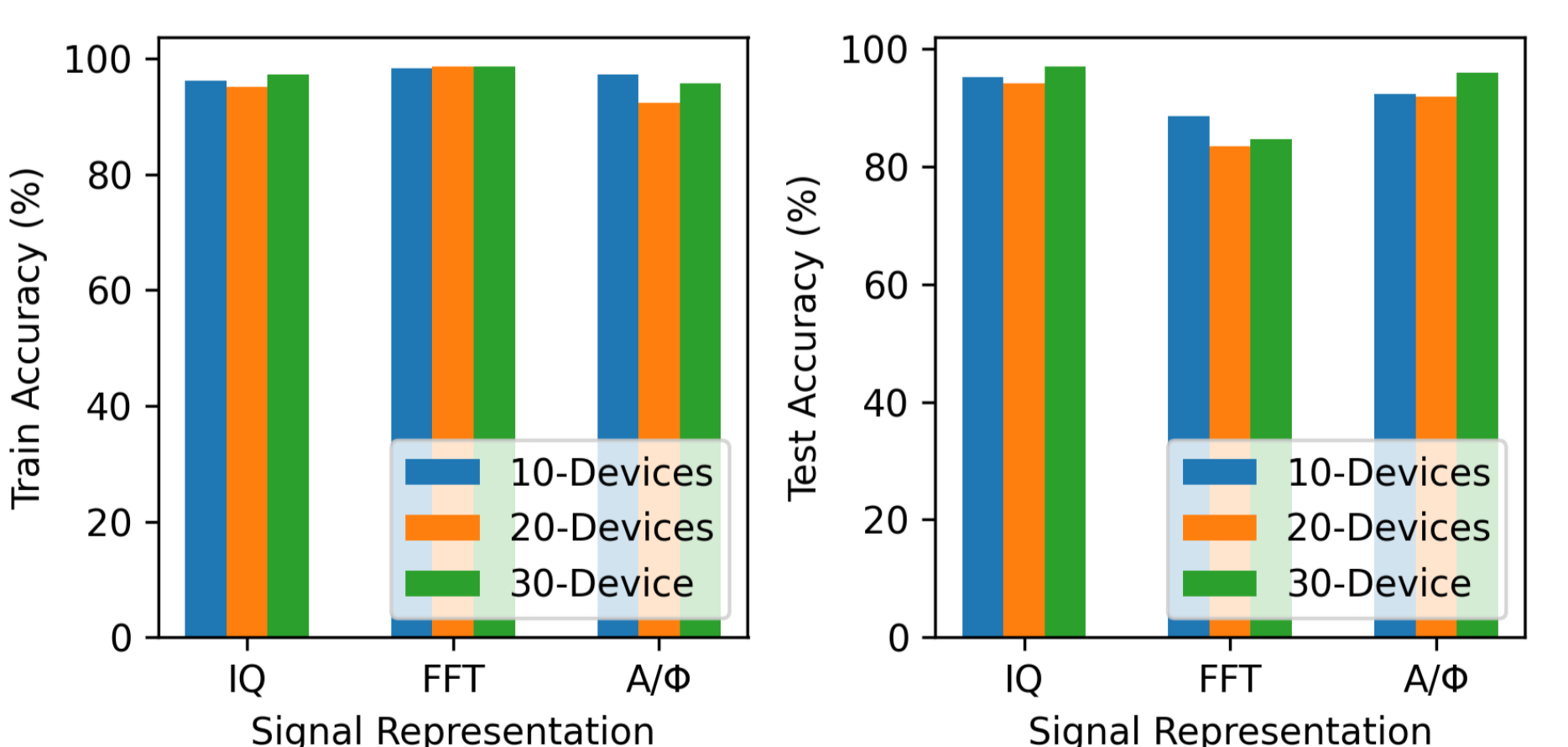


Fig 5: 1D-CNN train and test accuracy using different signal IQ, FFT and Amp/Phase

Table I: 1D-CNN Model Accuracy Vs # of devices over different signal representations

# devices	Train Accuracy (%)			Test Accuracy (%)		
	10	20	30	10	20	30
<b>1D-CNN</b>						
<b>IQ</b>	96.24	95.21	97.26	95.20	94.21	<b>97.06</b>
<b>A/φ</b>	97.25	92.42	95.82	92.33	91.86	95.91
<b>FFT</b>	98.38	98.72	98.62	88.62	83.53	84.74

Table II: Original Vs Optimized ResNet Models Performance (30 Devices)

Model	Parameters	Reduc. (%)	Train time (s)	Accuracy		Size (MB)
				Train	Test	
<b>Original</b>	12,475,422	0.00	1048	99.97	99.39	95.3
<b>Opt. 1</b>	6,203,150	50.28	668	99.97	98.93	47.5
<b>Opt. 2</b>	3,099,030	75.13	773	99.92	98.58	23.8
<b>Opt. 3</b>	1,554,842	87.55	540	99.23	78.63	12.0
<b>Opt. 4</b>	1,558,886	87.55	575	99.89	<b>97.42</b>	<b>12.0</b>

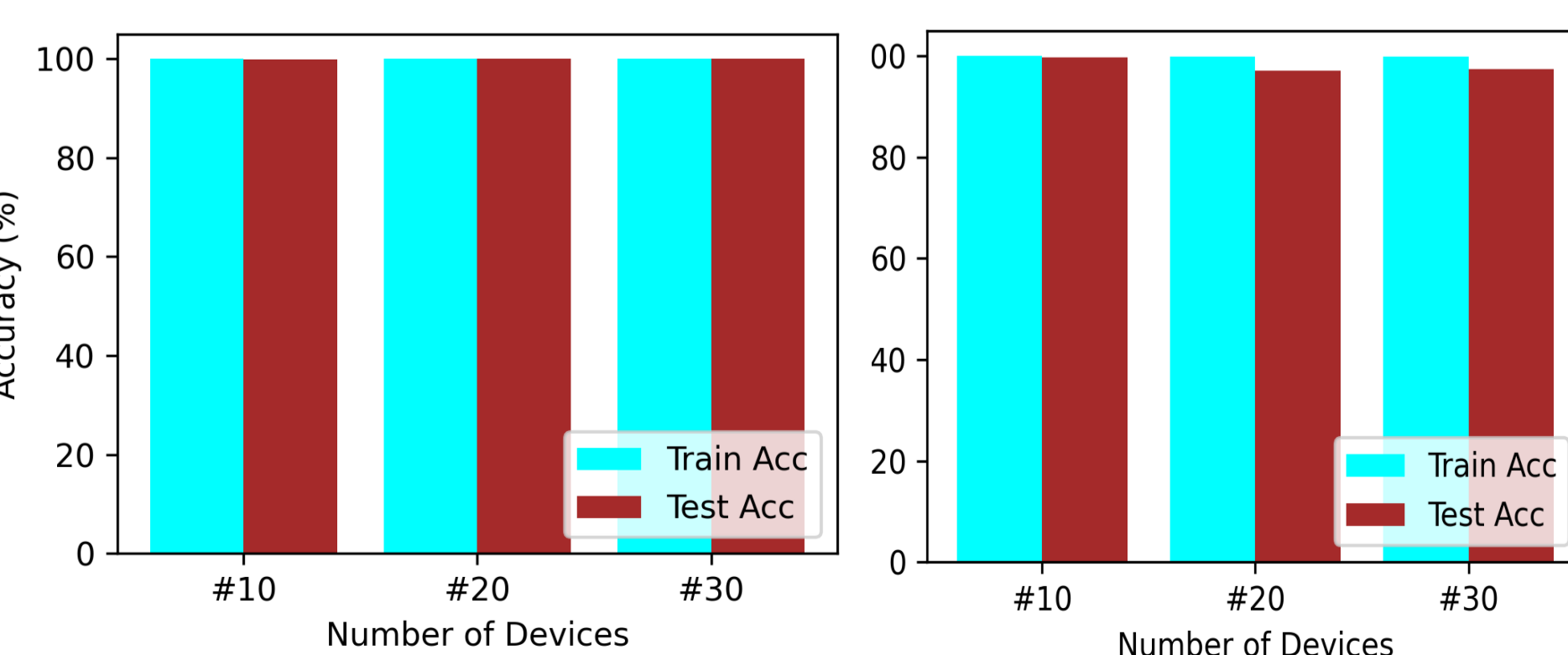


Fig 6: Optimized ResNet train and test accuracy using Spectrogram

Ref: \*G. Shen, J. Zhang, A. Marshall, and J. R. Cavallaro, "Towards scalable and channel-robust radio frequency fingerprint identification for lora," IEEE Transactions on Information Forensics and Security, vol. 17, pp. 774-787, 2022