A STUDY OF COST-EFFECTIVE MINI-SERVER SYSTEM USING AN ANDROID TV BOX TX3 MINI

Truong-Sinh Truong, Lam-Huy Thach, Hoang-Phi Chau, Hoang-Hiep Dang, Duc-Duy Le, Duc-Duy Tran, Anh-Duc Nguyen, Minh-Tam Nguyen *

Ho Chi Minh City University of Technology and Engineering (HCMUTE)
Vo Van Ngan Str., No. 01, Ho Chi Minh City (HCMC), Vietnam
* Corresponding author. E-mail: tamnm@hcmute.edu.vn

Abstract: This research focuses on the successful implementation of a cost-effective mini-server by reusing an Android TV Box TX3 Mini running the Armbian/Linux operating system. The results demonstrate that this is a viable and energy-efficient alternative to the Raspberry Pi, whose costs are increasing. With an initial investment cost of only about 33 USD and a low power consumption of 3.5 W in standby mode, the device achieves outstanding economic efficiency. The server has been tested and shown to perform well for light-load services such as static web hosting (NGINX Web Server) and file sharing (Samba File Server), achieving a network speed of 94 Mbps and a CPU performance of 650 events/s. This success not only provides a low-cost personal server solution but also makes a practical contribution to the circular economy, helping to reduce e-waste.
Keywords: Cost-effective, mini-server, TX3 Mini, Armbian/Linux, e-waste.

1. Introduction

In recent years, the development of the Internet of Things (IoT) and the need for personal storage has promoted the deployment of compact, low-cost servers for households, user groups, and individuals. Therefore, the use of embedded devices such as Raspberry Pi, Orange Pi that can act as web servers has become popular and widely applied in daily life because of their much lower power consumption than traditional computers. However, the cost of embedded devices has increased significantly in recent years, making this solution less suitable for people with limited budgets. Some recent studies, such as [1] Repurposing of TV boxes for a circular economy in smart cities applications have tested the reuse of TV Box. However, this work is experimental with many purposes and has not yet produced a real product.

Along with the continuous development of technology, the trend of integrating smart platforms (such as Android TV, WebOS, Tizen) into TVs has made many low-cost Android TV Box devices, such as the TX3 Mini, redundant and unused. This rapid obsolescence creates a potential source of wasted hardware resources. In particular, [2] this situation contributes to a significant increase in the amount of electronic waste (e-waste), a global challenge. Therefore, finding solutions to reuse old hardware such as the TX3 Mini is not only an economic solution but also a practical contribution to the circular economy, helping to reduce electronic waste.

This gap opens up the opportunity to systematically research the reuse of TV Boxes, specifically the TX3 Mini as a personal server to take advantage of available or cheaper hardware, reduce investment costs for systems with small servers, and contribute to reducing electronic waste. Therefore, this research focuses on deploying the TX3 Mini as a server using the Armbian/Linux operating system, then compares it with the Raspberry Pi, which is currently the most popular embedded device used as a server.

2. Model

Total Cost Model:

$$C_{total} = C_{hardware} + C_{energy} + C_{maintenance} \quad (1)$$

- $C_{hardware}$: Hardware cost : 28 USD
- C_{energy}: Energy consumption cost over time ($C_{energy=} P_{device} \times T_{uptime} \times C_{electricity}$)
- $P_{devicemax}$: Maximum device power (TX3 Mini: 10W)
- $P_{devicemax}$: Maximum device power (TX3 Mini: 10W)

Thus, the energy consumption if used continuously for 1 month is:

E= 10 x 24 x 30 =1800Wh =7.2 kWh

$C_{energy=}$ 7.2 x 0.13 = 1 USD/ month

- $C_{maintenance}$: Maintenance and accessory costs (cables, memory card, adapter): 4 USD

Thus, the total cost for the first year of use is Ctotal = 33 USD

Preliminary comparison with Raspberry Pi 4:

Tab. 1. Preliminary Electricity Consumption and Cost Comparison

	TX3 Mini	Raspberry Pi 4 (2GB)
Hardware	28 USD	68.8 USD
P_{max}	10W	15W
$C_{energy=}$	1 USD	1.4 USD

The TX3 Mini is approximately 50% cheaper in both investment cost and electricity cost.

TX3 Mini Technical Specifications:

Fig 1. Interface Android TV Box TX3 Mini

CPU: Amlogic S905W, Quad-core ARM Cortex-A53:GPU: Mali-450 (5 cores, 750 MHz)
RAM: 1GB / 2GB DDR3
eMMC: 16GB
WiFi: 802.11 b/g/n (2.4 GHz)
LAN: RJ45 100M
Power Supply: DC 5V / 2A (≈ 10W max, typically ~2.5W in server mode)

System Structure Model: The proposed server structure model is a system that reuses hardware (TX3 Mini) and deploys open-source software (Armbian/Linux) to provide network services.

Tab. 2. TX3 Mini Technical Configuration and Role in Server Model

Component	TX3 Mini(Amlogic S905W)	Role in Server Model
CPU	Quad core ARN cortex-A53	Processes server tasks (Web, SSH, Container)
RAM	1GB/2GB	Memory for Armbian OS and services
Memory	16GB eMMC	Main storage for the operating system
LAN	RJ45 10M/100M	Main network connection port (Limitation: 100Mbps)
Operating system	Armbian(Kernel 5.15.15+)	Optimized Linux OS, providing the server environment
Workload	NGINX, Docker, Samba	Actual applications for performance testing

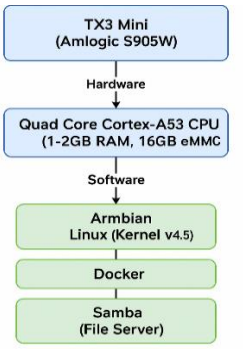

Fig. 2. System structure model.

This flowchart shows the layered relationship between hardware and software in the proposed mini server model. Structural principles:

Hardware layer: The physical platform, including TX3 Mini (Amlogic S905W) with core components: Quad Core Cortex-A53 CPU, RAM (1-2GB), and 16GB eMMC storage.

Operating System layer: Armbian Linux (Kernel v4.5/5.15.15+) is installed on the hardware, providing an optimal server environment.

Application/Workload layer: Specific applications are deployed to provide network services, including Docker (to run standalone services) and Samba (to share files).

3. Method

Research Procedure

Prepare Equipment and Tools:

- TX3 Mini, microSD memory card, 5V/2A power adapter.
- Download Armbian for Amlogic S905W.

Install Operating System:

- Flash Armbian onto the memory card, boot via SD card.
- Configure SSH, static IP, and automatically starting services.

Install and Test Services:

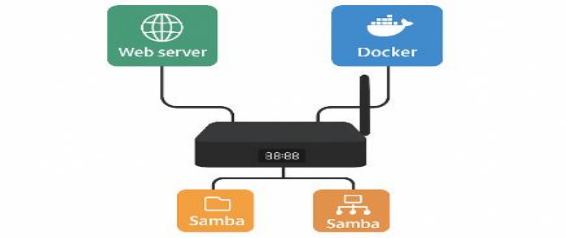

Fig. 3. Practical applications.

- Web server(Nginx) : An open-source web server used to serve websites and API applications via HTTP/HTTPS protocol. It can also act as a reverse proxy, load balancer, or HTTP cache.

  Role in the system:

  When a user accesses your IP address or domain (e.g., http://192.168.1.10), Nginx is the software that receives and responds to that request. It sends HTML content, images, videos, or API data to the user's browser.

  Advantages: Very light, fast, consumes little RAM. Easy to configure, supports thousands of simultaneous connections.

  Configuration commands:

  sudo apt install nginx
  sudo systemctl start nginx

- Docker : A technology that packages applications and necessary components (libraries, environment, configuration) into a

container—an independent environment much lighter than a virtual machine.

Role: Used to run multiple independent services on the same TX3 Mini without conflicts (e.g., web server, database, mqtt broker, media server, etc.).

Advantages: Very light, quick start-up. Easy to backup and restore the entire application.

Configuration commands:

```
sudo apt install docker.io
sudo docker run -d -p 8080:80 nginx
```

(This command launches the Nginx web container on port 8080).

- File Server chia sẻ mạng (Samba): Open-source software for sharing files and folders over a local network, fully compatible with Windows systems (SMB/CIFS protocol).

Rol*e:* Allows a Linux system to access TX3 Mini folders as a network drive (e.g., you save movies, documents, or data backups to the TX3 Mini and access them from another computer via Wi-Fi).

Advantages: Easy to configure, lightweight, suitable for a mini-server. Can grant permissions by account.

Configuration commands:

```
sudo apt install samba
sudo nano /etc/samba/smb.conf
```

Tab. 3. Application Technologies and Functions on the TX3 Mini Mini-server

Technology	Main Function	Application on TX3 Mini
NGINX	Web server, reverse proxy	Runs internal website, API, dashboard
Docker	Runs multiple services in independent containers	Deploy NGINX, MQTT,database
Samba	File sharing over LAN	Uses TX3 Mini as a NAS network drive

Experimental Evaluation:

- Measure power consumption, CPU performance, network speed.
- Compare with Raspberry Pi 4.

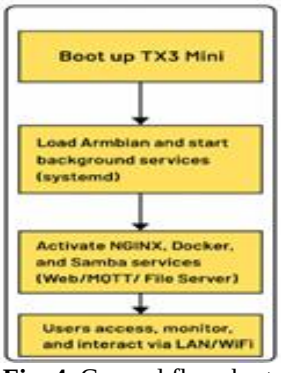

Fig. 4. General flowchart.

This flowchart describes the sequence of steps the TX3 Mini system performs when powered on, ensuring continuous (24/7) server services. How it works:

Hardware boot: TX3 Mini is powered on (Boot up TX3 Mini).

OS loading: The system loads Armbian and starts background services via systemd.

Server service activation: After the operating system is stable, the main services such as NGINX (Web/API Server), Docker (Containerization), and Samba (File Server) are activated.

Ready to serve: Users can access, monitor, and interact with these services via LAN/WiFi.

Measurement Methods:

- Performance: Use sysbench, Apache Benchmark (ab).

Sysbench Used to assess overall system performance, including:

CPU: Checks the speed of mathematical operations via the CPU test.

Memory Evaluates RAM read/write speed and data access.

I/O: Checks disk read/write performance.

Database: Measures query processing speed in MySQL or MariaDB environment.

Test commands:

```
sysbench cpu –cpu-max-prime=20000 run
sysbench memory run
sysbench fileio –file-total-size=1G prepare
sysbench fileio –file-total-size=1G –file-test-mode=rndrw run
```

Apache Benchmark(ab) Used to assess web server or API performance. Metrics obtained include:

Requests per second(RPS)

Time per requests

Failed requests

Test commands:

```
ab -n 1000 -c 50 http://localhost/
```

Ss (where -n is the total number of requests, -c is the number of concurrent requests).

Operating Temperature: Use vcgencmd and sensors to measure CPU temperature, evaluating heat dissipation and stability under high system load. Monitor and record average, maximum, and temperature increase during the benchmark process.

Execution commands:

```
vcgencmd measure_temp
sensors
```

- System Stability**:** Use uptime to record the continuous operating time of the system without requiring a restart.

Execution commands:

```
uptime
```

4. The Experiment

4.1. Real Model

The actual model is deployed based on the principles of hardware reuse and open-source software, aiming for optimal performance at low cost.

Tab. 4. Actual Server Model Configuration Details

Component	Configuration Details
Hardware (DUT)	Android TV Box TX3 Mini
Operating System	Armbian(Linux)
Boot MemoryRole in the system	16GB eMMC
Workload	NGINX (Web Server), Samba (File Server), Docker (Containerization)
Communication	Minicom 2.9 qua Serial Console

Software Configuration:

- Operating System: Armbian successfully booted from the memory card, static IP address set up.
- Web Server: NGINX installed to run a basic static website.
- File Server: Samba installed for file sharing on the local network.
- Container: Docker installed to run a basic Pi-hole container (ad-blocking DNS server).

4.2. Experimental Results

Experiments were conducted to measure computing performance, data transfer capability, and actual power consumption of the TX3 Mini when operating as a 24/7 server.

The command : sudo mini

Is used to launch Minicom, a terminal program simulating communication via the serial console.

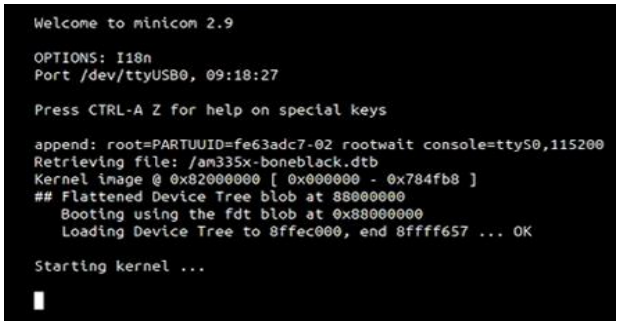

Fig. 5. Experimental results.

The screen shows Minicom 2.9 starting the Kernel and Device Tree Blob (DTB) loading process.

This proves successful console connection and that the Armbian operating system (or equivalent) is starting on the TX3 Mini hardware.

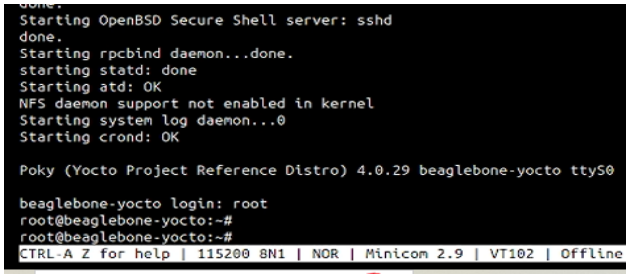

Fig. 6. Experimental results.

The screen successfully displays the login prompt (Shell Prompt) root@beaglebone-yocto:~#

This process includes:

- reading device configuration (dtb).
- Initializing hardware drivers (USB, network, eMMC/SD/MMC storage – mmcblk, etc.).
- Starting init and system services (udev, sshd, networking).
- A final message confirming the system has booted and logged into the console as root.

This proves that the Linux operating system has completed the boot process and is ready to receive commands, confirming that the server environment is operational.

The command uname -r is used to print the running kernel version.

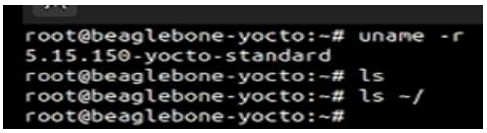

Fig. 7. Experimental results.

The screen displays the command uname -r and the result **5.15.150-yocto-standard.**

This provides specific evidence of the running Linux Kernel version, confirming the stability and compatibility of the operating system with the Amlogic S905W chip.

Tab. 5. Summary of TX3 Mini Performance and Energy Consumption Measurement Results

	Metric	Comment
Pdevice at idle	3.5 W	Actual measurement when running Armbian (idle), much lower than the maximum 10W.
Sysbench	650 events/s	Lower speed compared to Raspberry Pi 4. Raspberry Pi 4 average speed is usually > 1000.
LAN Speed (iPerf3)	94 Mbps	Limited by the physical 100BASE-T port.
File Transfer Speed (Samba)	≈9.5 MB/s	Consistent with 100Mbps LAN speed.
SD/eMMC Read Speed	≈100 MB/s (eMMC Read)	Storage I/O speed is fast enough, but network speed drags it down.
Web Server Performance (NGINX)	≈350 req/s	Strong enough to serve personal/light-load websites.

After completing the Armbian/Ubuntu environment installation, the JupyterLab system was deployed. This allows users to develop, test and visualize source code directly on a simulated miniature server environment for the TX3 Mini..

Installation command:

```
sudo apt update
sudo apt install python3 python3-pip
mkdir my_jupyter_project
cd my_jupyter_project
  python3 -m venv env
  source env/bin/activate
  pip install jupyterlab
  jupyter lab
```

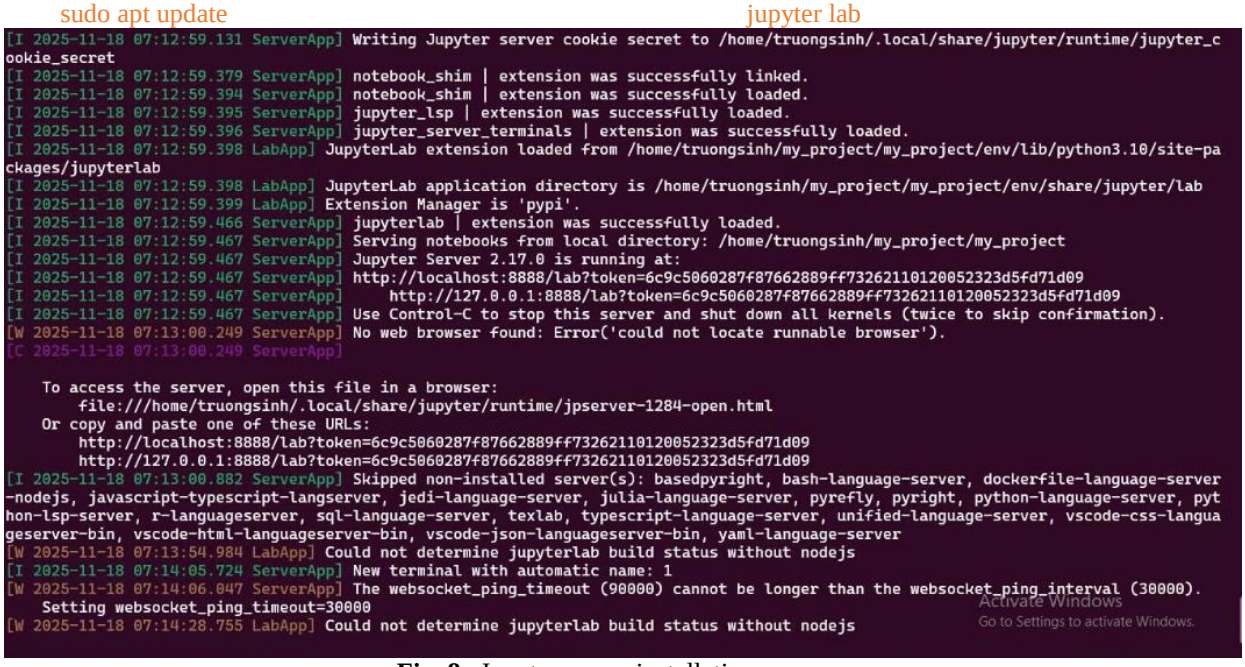

Fig. 8. Jupyter server installation process.

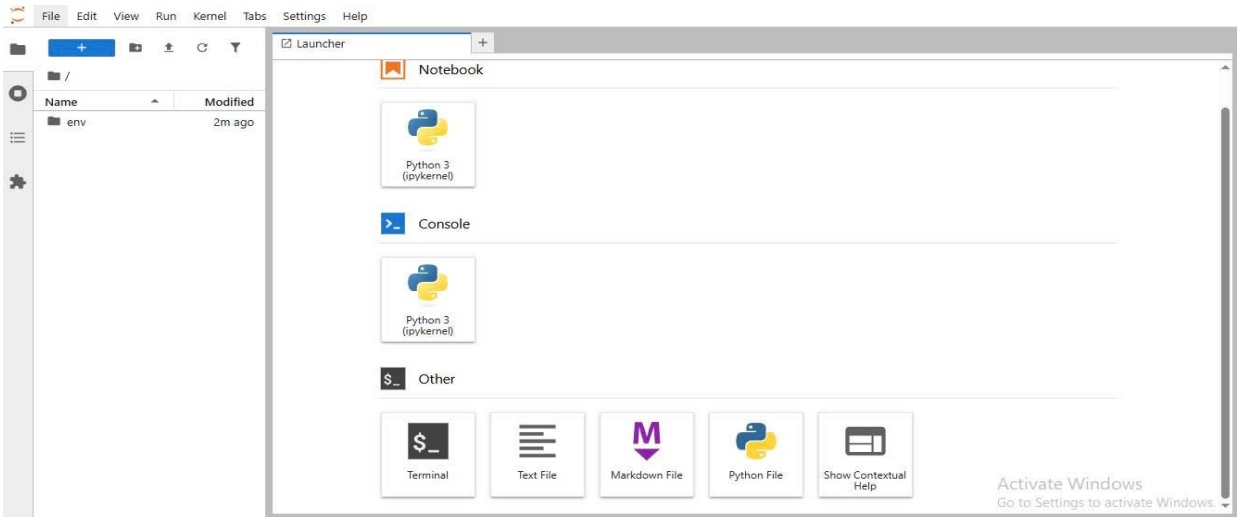

Fig. 9. Jupyter server interface.

TX3 Mini has now become a Mini Jupyter Server for: Python programming, Running light AI (small computations), Testing IoT data, Storing - analyzing data from onboard sensors or small servers.

The integration of Jupyter Server on TX3 Mini helps the device not only act as a simple IoT server, but also become a complete data analysis and algorithm development platform, effectively serving applications such as: Remote ship status monitoring, Environmental monitoring system, Smart home,… This contributes to enhancing the reuse value of the TV Box, turning a low-cost device into a flexible, energy-saving and powerful mini server.

4.3. Comment

Advantages:

- The TX3 Mini is capable of stable 24/7 operation for small web services, IoT, or file sharing. Performance is lower than Raspberry Pi, but the cost and power consumption are only 50%.

- Actual power consumption of only 3.5W proves the TX3 Mini is a „green server" device, ideal for 24/7 operation.
- Stable operation of Linux Kernel 5.15 proves the success of repurposing old hardware, contributing to reducing e-waste.

Disadvantages:

- The 100Mbps network speed is the most apparent weakness. This makes the TX3 Mini unsuitable for applications requiring high bandwidth such as large capacity NAS backup or 4K media servers.
- Low computing performance, not suitable for heavy workloads or processing many concurrent tasks.

Suggested improvements:

- Increase Network Speed: Experiment with using a USB 2.0 to Gigabit LAN Adapter (if compatible with the Armbian kernel) to overcome the 100Mbps limitation of the built-in Ethernet port.
- Operating System Optimization: Disable all unnecessary modules and services (e.g., GPU, HDMI output) in Armbian to further reduce power consumption and free up RAM, improving C_{energy} and C_{total} performance.
- Storage Expansion: Recommend using an SSD via the USB port (instead of a memory card) to improve durability and increase read/write speed for storage tasks.

5. Conclusions

This study successfully deployed a cost-effective mini-server model by repurposing the Android TV Box TX3 Mini running the Armbian/Linux operating system.

Tab. 6 Evaluation of Experimental Results Compared to Project Objectives

Goal	Experimental Results	Value
Feasibility	Successful boot of Linux Kernel 5.15.150-yocto-standard.	Confirms the TX3 Mini can be fully repurposed as a Linux server platform.
Cost Efficiency	Initial investment cost ≈33 USD; Actual power consumption ≈3.5 W (Idle).	An extremely cost-effective and energy-efficient mini-server solution (>50% compared to Rpi 4).
Performance	CPU performance is sufficient for light load (650 events/s); Network speed 94 Mbps.	Suitable for light-load services such as Pi-hole, static Web Server, Home Assistant.

Application Value:

Cost Savings and Circular Economy**:** Provides a financially effective alternative to the increasingly expensive Raspberry Pi, while contributing to the circular economy by reducing e-waste through the reuse of old equipment.

Lightweight Personal Server:

Ideal for users who need to deploy basic server services in the home or small office, where 24/7 operating cost is a top priority.

Future Work:

Applications in Remote Control and Communication Systems on Marine Ships: Due to its extremely low power consumption (3.5W) and stable 24/7 operation, future work will focus on applying this system as an embedded computing unit on marine ships. The device can run communication services (e.g. MQTT Broker or Web Dashboard) to collect and transmit sensor data (location, speed, fuel level) or send remote control commands via satellite or 4G connection. This takes advantage of the low cost and energy efficiency of the TX3 Mini in environments that require a sustainable and low-power solution.

Acknowledgement

We want to give thanks to Assoc Prof. Van-Ca Phan (HCMUTE) due to his supervision for this contribution. Link of video of operation is shown in: https://youtu.be/PVzj-7r8hNM

6. References

[1] Gustavo P. C. P. da Luz et al: "Repurposing of TV boxes for a circular economy in smart cities applications", Sci Rep, 15(1): 22638, 2025.

[2] Balde, C. P. Et al: "The Global E-waste Monitor 2017: Quantities, flows, and resources: 2017", ISBN: 978-92-808-9053-2, 2017.

[3] Bauer R., Varela-Rodríguez M. "Low-Cost Hardware for IoT Applications: Repurposing Old Electronics", Proceedings of the IEEE International Conference on Smart Cities (SmartCity), 2020.

[4] Minott D. et al: "Benchmarking Edge AI Platforms: Performance Analysis of NVIDIA Jetson and Raspberry Pi 5 with Coral TPU", Proceedings of the IEEE International Conference on Smart Cities (SmartCity), 2025.

[5] Kim S.S., Lee S.K.: "Performance Analysis of Low-Cost Amlogic-based Devices for IoT Edge Computing", Journal of Computer and Communications, 2021.