A Frame-Based Architecture for Enhanced Secure IoT Communication with Ascon-128a

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MOTIVATION

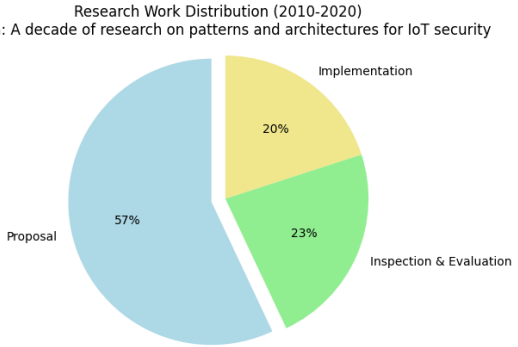
- Most IoT devices operate with constrained computational capabilities and limited resources.

Table 1: Classification of IoT devices based on hardware capabilities.

Category	CPU	RAM	Storage	Power	Example
Category 1	8-bit, 16 MHz	$\leq$ 32 KB	Small	$\leq$ 1 W	Arduino Mega
Category 2	32-bit, 80 MHz	32–80 KB	Small	$\leq$ 1 W	NodeMCU ESP-12
Category 3	Single-core, 1 GHz	80 KB–512 MB	$\leq$ 4 GB	1–2 W	Raspberry Pi Zero
Category 4	Quad-core, 1.2 GHz	512 MB–2 GB	$\leq$ 8 GB	2–4 W	Raspberry Pi 3
Category 5	Quad-core, 2 GHz	$\geq$ 8 GB	$\geq$ 32 GB	High	Jetson TX2

MOTIVATION

- Research on implementing complete IoT architectures remains limited.

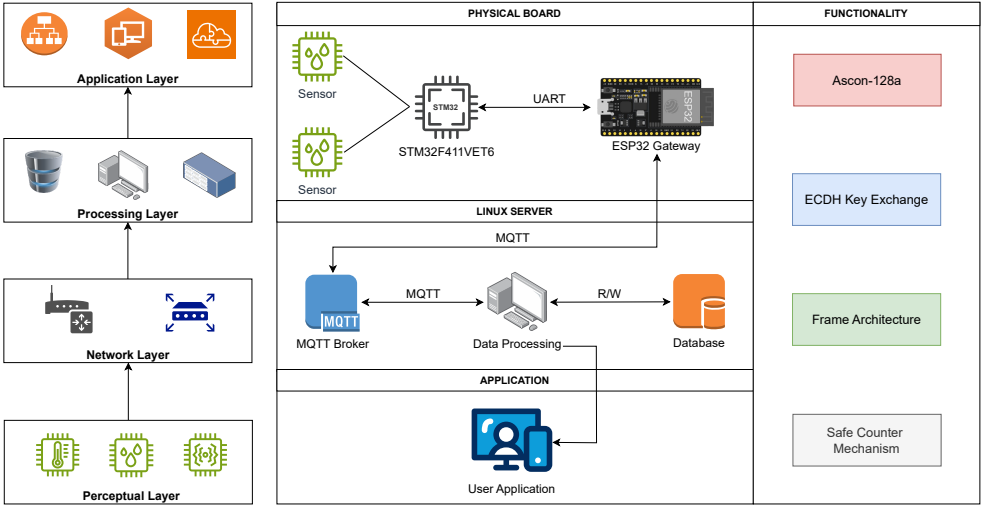


OBJECTIVES

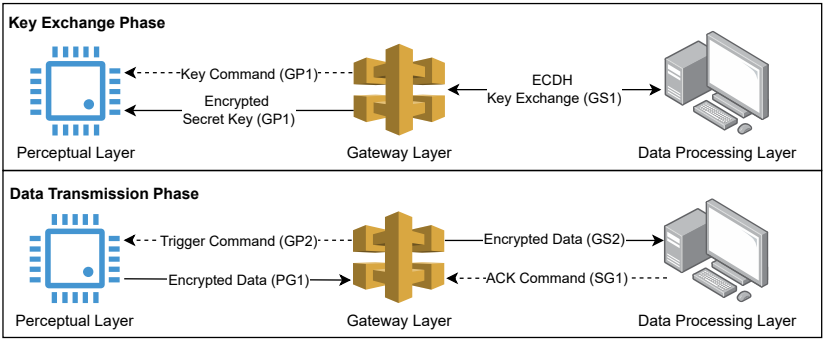
This work aims to develop a complete IoT architecture that fulfills the following goals:

1. Compatible with a **wide range** of hardware platforms.
2. Ensures **data integrity** and **confidentiality** during transmission.
3. Provides mechanisms to **mitigate common attacks**.
4. **Implementation** on real hardware and performance benchmarking.
5. Can be used as a **reference** framework for future IoT implementations.

SYSTEM ARCHITECTURE

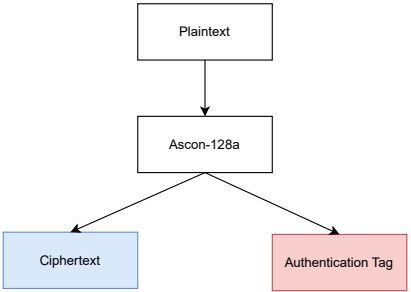


COMMUNICATION MODEL

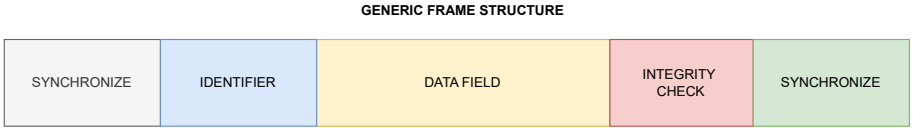


THE ASCON-128a LIGHTWEIGHT CRYPTOGRAPHY

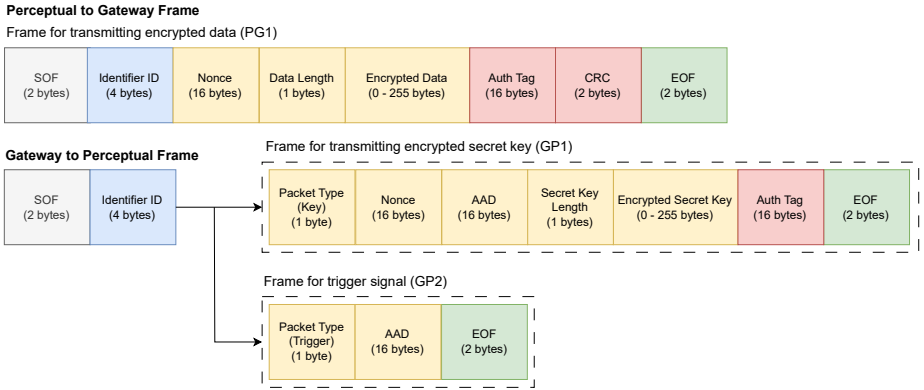
- Finalist of the NIST Lightweight Cryptography Standardization.
- Designed for constrained devices.
- Support AEAD providing both confidentiality and integrity.
- Used in this system to encrypt data and generate Auth Tag for each frame.



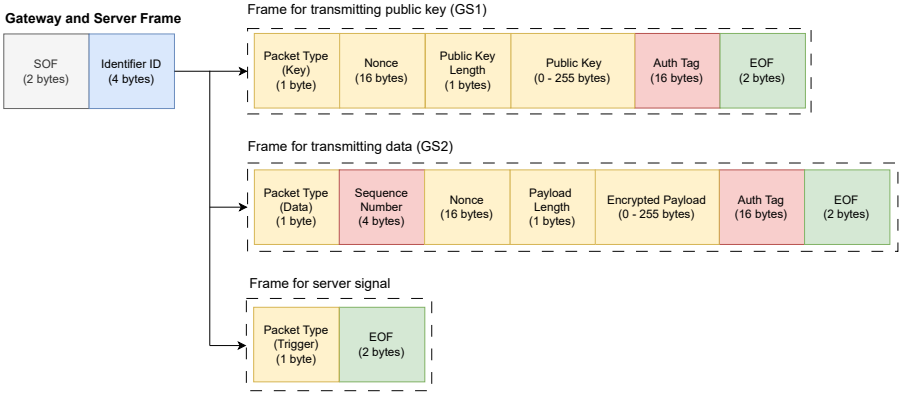
FRAME ARCHITECTURE



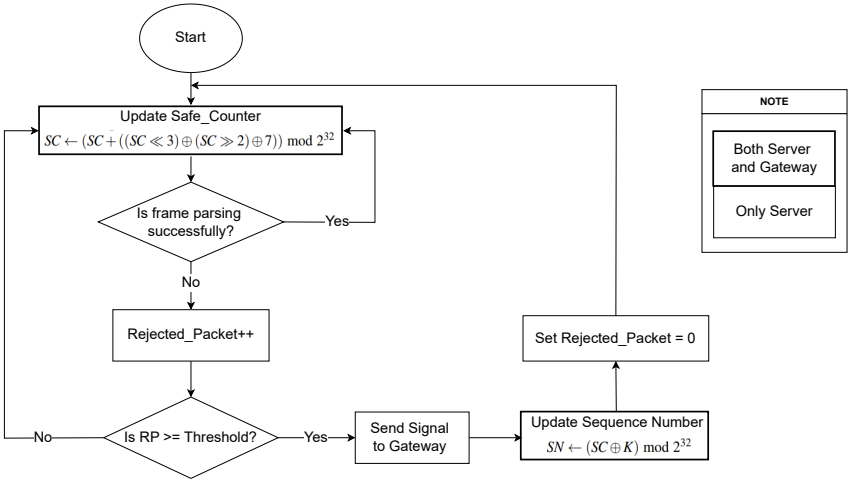
FRAME ARCHITECTURE



FRAME ARCHITECTURE



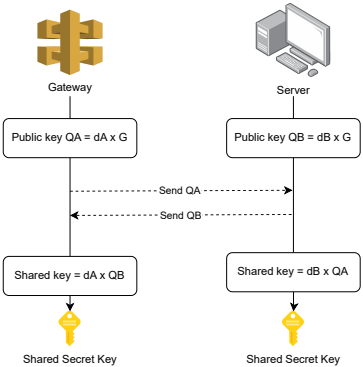
SAFE COUNTER MECHANISM



DYNAMIC KEY EXCHANGE

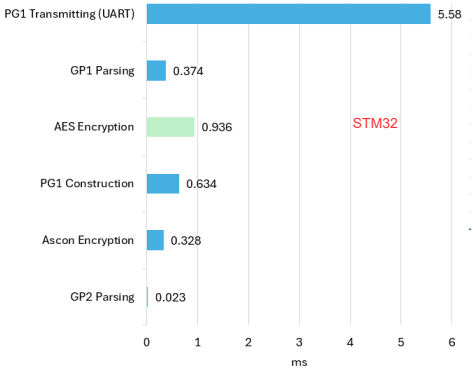
Frame for transmitting public key (GS1)

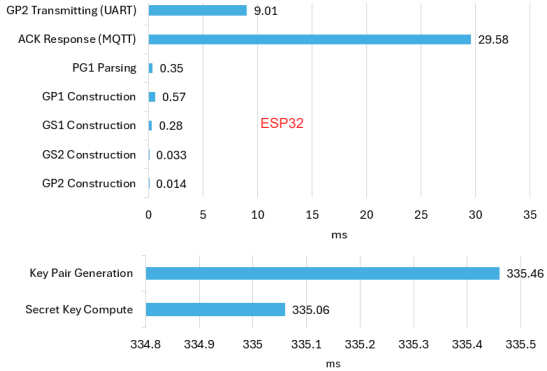
SOF (2 bytes)	Identifier ID (4 bytes)	Packet Type (Key) (1 byte)	Nonce (16 bytes)	Public Key Length (1 bytes)	Public Key (0 - 255 bytes)	Auth Tag (16 bytes)	EOF (2 bytes)



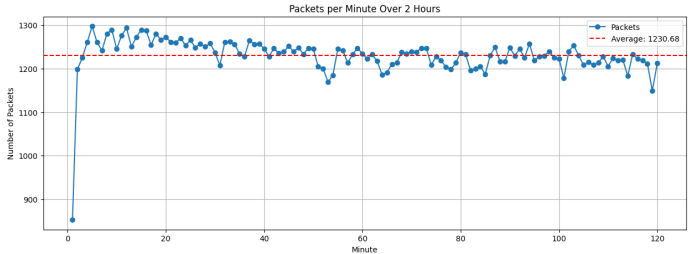
TIME EXECUTIONS

Total transmission time averages 49.91 ms.



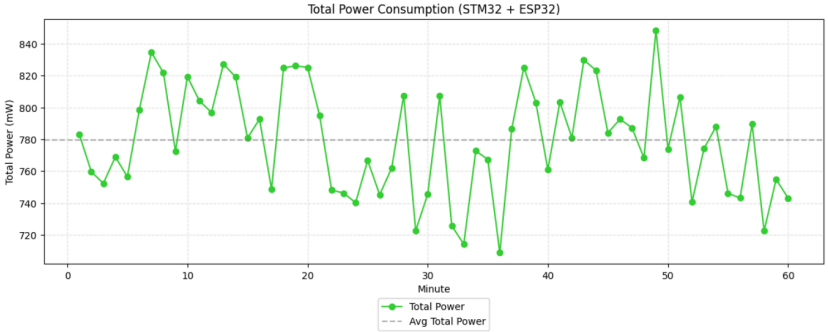


PACKET DELIVERY RATIO



POWER CONSUMPTION

Total power consumption averages 779.43 mW.



PAYLOAD EFFICIENCY

Analyze based on the GS2 frame.

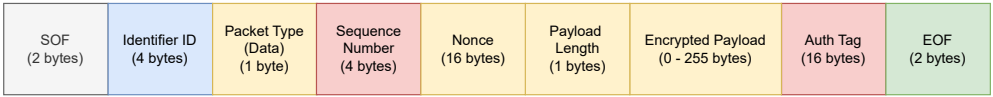


Table 2: Payload efficiency with different payload lengths

Payload Length	Total Frame Size	Efficiency
3 bytes	49 bytes	6.12%
10 bytes	56 bytes	17.85%
20 bytes	66 bytes	30.30%
50 bytes	96 bytes	52.08%

$\Rightarrow$ The larger the payload, the higher the payload efficiency.

ACHIEVEMENTS

1. A complete IoT architecture has been proposed and implemented.
2. Demonstrated compatibility with Category 2 and 3 devices (STM32F4 and ESP32).
3. Integrated Ascon-128a and ECDH for lightweight encryption and key exchange.
4. Combined frame-based communication with ECDH to offer a reliable key exchange protocol.
5. Enhanced integrity through frame structure and the Safe Counter mechanism.
6. Performance benchmarking has been conducted and analyzed.

FUTURE WORK

1. Research on key exchange protocol to reduce time overhead.
2. Design a data aggregation mechanism to improve payload efficiency.
3. Investigate techniques for reducing overall power consumption.

Thank you for your attention!