Energy Efficient Decentralized Authentication in Internet of Underwater Things using Blockchain

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P4-to-blockchain: A secure blockchain-enabled packet parser for software defined networking

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Blockchain-enabled Authentication Handover with Efficient Privacy Protection in SDN-based 5G Networks

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BlockIPFS - Blockchain-enabled Interplanetary File System for Forensic and Trusted Data Traceability

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Internet of Things (IoT)

- Wearable devices (e.g. smart uniforms with motion sensors and monitoring for threat awareness)
- Portable (but not wearable) devices and apps
- Less portable / stationary devices

- Many applications (medical – IoMT, battlefields – IoBT, industry – IIoT, etc.)
- *Security and privacy are two of many ongoing research and operational challenges*

Most (IoT) systems are not designed with security in mind!

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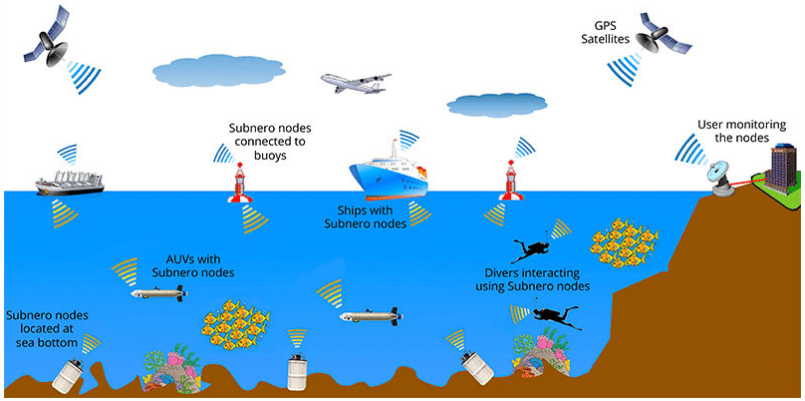
Internet of Underwater Things (IoUT)

- Nearly 70% of the Earth's surface is covered by water and a large proportion of underwater environments are still unknown and have not been explored
- With the increasing growth of IoT and its entry into all areas of urban life including water environments
- IoUT can be defined as a network of smart devices interconnected in an underwater environment

IoUT applications

- It made of unmanned vehicles that scour the sea while communicating with underwater sensors and sending the information to networks atop the surface.
- Environmental monitoring
- Underwater exploration



Felemban, Emad, et al. "Underwater sensor network applications: A comprehensive survey." *International Journal of Distributed Sensor Networks* 11.11 (2015): 896832

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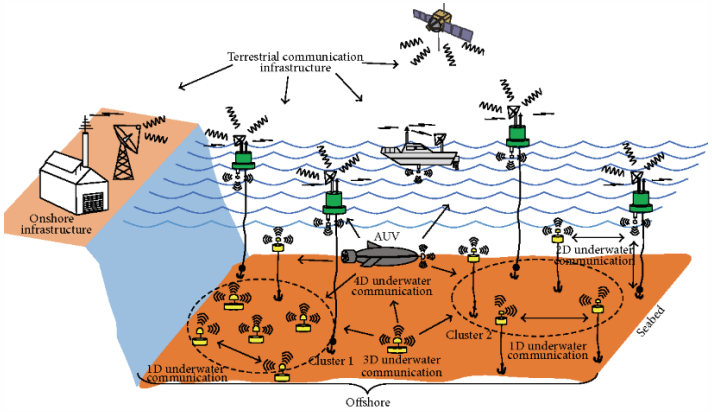
IoUT applications

- Disaster prevention
- Monitoring the health of animals
- Oil and Gas



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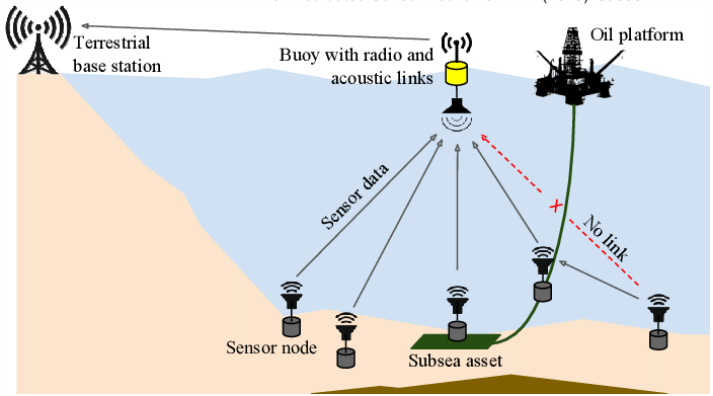

Morozs, Nils. "Unsynchronized dual-hop scheduling for practical data gathering in underwater sensor networks." *2018 Fourth Underwater Communications and Networking Conference (UComms)*. IEEE, 2018.

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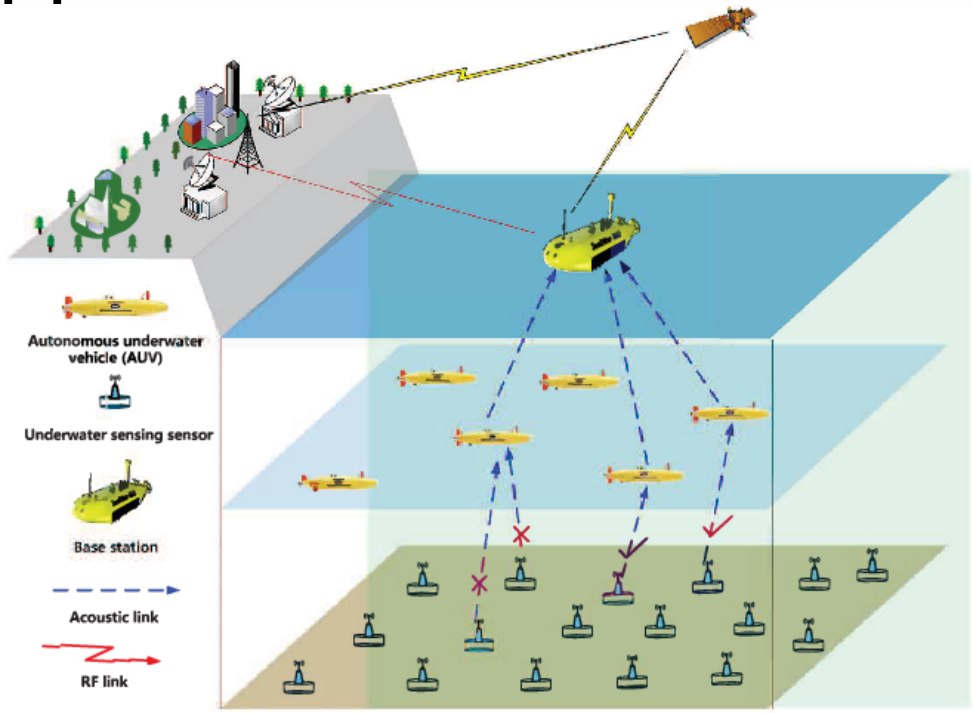
IoUT applications

- Military



Li, Xinbin, et al. "Relay selection for underwater acoustic sensor networks: A multi-user multi-armed bandit formulation." *IEEE Access* 6 (2018): 7839-7853

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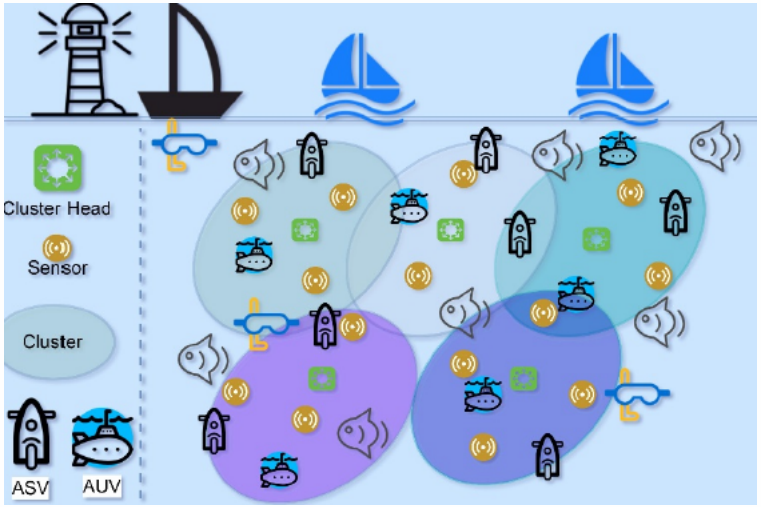
IoUT-specific issues

- Long-term isolated environments…
- Most of the classic authentication methods and centralized security mechanisms require a trusted third-party
- The lack of security in design, inability to defend against attacks, resource constraints…
- The *mobility* of IoUT devices and the frequent switching between clusters, there is a need for frequent authentication to identify and authenticate devices which can require high energy use, unacceptable for IoUT

Proposed approach (Preliminary work)

- Our solution is based on a cluster-based network of objects that uses distributed ledger technology (DLT) to allow secure exchange of data underwater (decentralized authentication).

✓ the IoUT devices in each cluster are connected through P2P networks using a blockchain mechanism (removing the need for re-authentication)



Underwater cluster-based network

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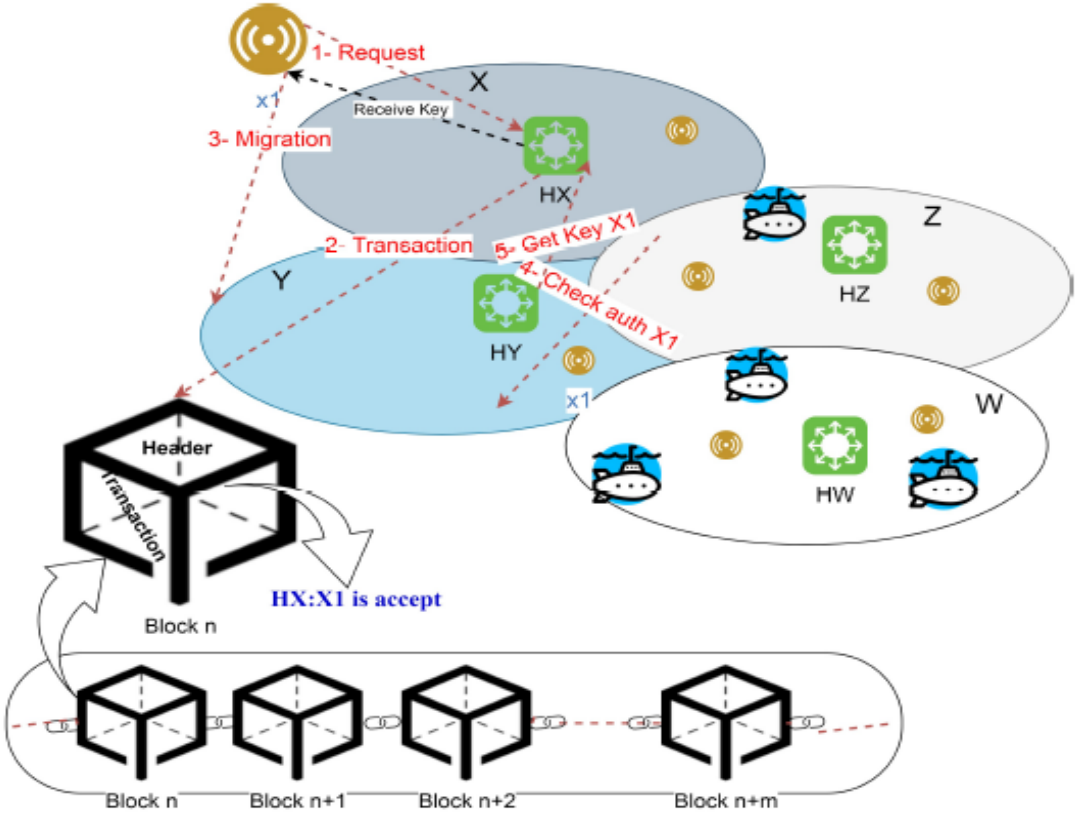
The architecture of the proposed method



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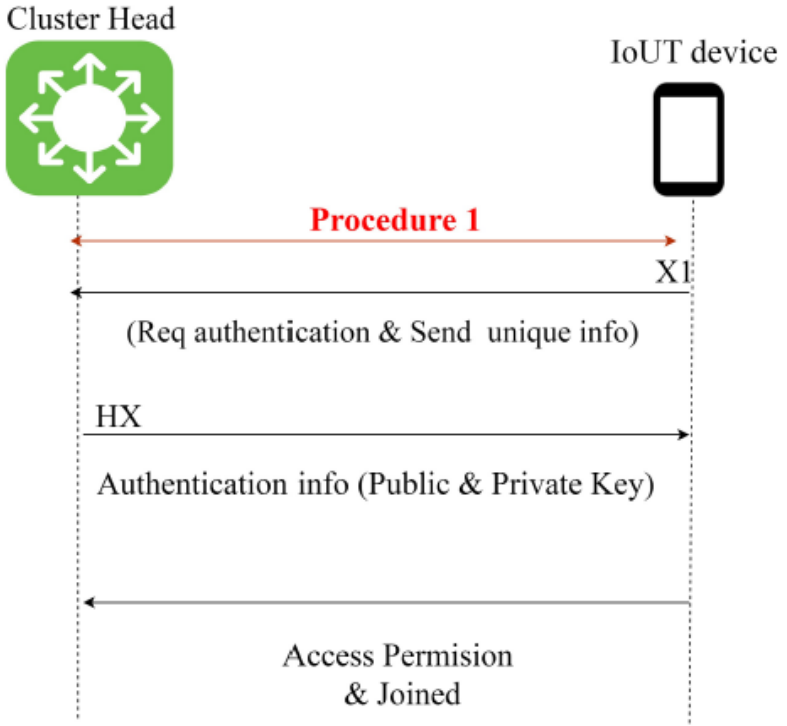
Procedure 1 : Joining a Cluster

- X1 is authenticated, and HX sends a transaction to the blockchain.
- X1 is trustful and HX shares a symmetric key for safe transfer with X1.
- These transactions are valid in a new block and are stored by HX.
- When X1 migrates to another cluster, for example, to cluster Y managed by HY, X1 sends a request to HY to join it.



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The process of migration and file transfer between IoUT devices

Algorithm 1 Migration mechanism among clusters

```
Call register (X1) // Reg devices in Cluster
Device X1 → Req authentication
HX → Send(authenticationvector (Public & Private/ Key))
Hash_Function (X1)
Node X1: receive (Hash 256)
Call Join_Cluster (X1) // join to cluster
    If (X1== Rang)
      auth = 1
      Calculate (mobility)
    else
      auth = 0
      Calculate (migration)
    While (auth = 0 ) do{
      if (Mobility = 1 or migration = 1)
        if (authenticate)) // in cluster
          HX: Message (X1)
          Update(cluster_info)
          Migrate(X1, current, Target)
      else
          Hx: Message (Blockchain)// send to BC Update X1
      }
While (migrate or mobility != 0 ){
    New_cluster_head = Received (data_X1)
    New_cluster_head = Decrypt (dataCreate header)
      }
end
```

Algorithm 2 Transfer files in cluster

```
Device X1 Announce to X2// User X1 wants to send information to User X2
    If (user X1== authentic in cluster && trust)
        HX (Check traffic cells)
        X1 calculate (optimize (path))
        X1 Encrypt (send data (dK)) // encrypt with Private key
        X1 = Send (WK)
        X2 = monitor_trust-data_ (X1)
    else
      Add to block ()
  X2= Received (data)
  X2 = Decrypt (data) // using private key and re-organize data
end
```

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Preliminary Results

- Using the NS-2 V2:35 simulation
  - Average energy consumption
  - Packet delivery rate
  - End-to-end delay
  - Authentication attacks

Simulation Parameters	Values
Simulator	NS-2.35
Type of channel	Wireless channel
Radio range of a node	Random
Propagation model	Propagation/Two ray channel
MAC protocol	Mac/802.11
Mobility model	Random waypoint model
Nodes speed	3 m/s
Number of IoUT Devices (sensor)	200 - 500
Link type of queue	Queue/Drop Tail
Number of Cluster	10
Traffic Type	Constant Bit Rate (CBR)
Type of Antenna	Antenna/Omni Antenna
Simulation Time (Second)	800
Evaluation parameters	End to End delay, delivery ratio, Energy consumption
Number of Simulation runs/scenario	30
Area	2500 m * 2500 m
Packet size	512 Byte
Length of packets (Cluster to BC)	32 Byte
Previous hash	16 Byte
Transaction counter	9 Byte
Block Header|Block Size	80|8 Byte

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- The proposed method was compared with a classic authentication method as given in through simulation.

✓ Specifically, the classic method does not consider the constraints of an underwater environment and cluster structuring.

✓ The given classical method needs to be re-authenticated during movement of nodes between clusters.

Evaluation Results

Measures	Classic	Proposed	Reduction (%)
Execution Time (sec)	24.450	12.405	49.26%
P_{com} (mW)	492628	246311	49.99%
Energy consumption (mJ)	12044	3055	74.63%

Equation Parameters	Description
N_t	Number of times a transmitter is switched "on"
P_t	Power consumed by transmitters (mW)
T_t	Transmitter "on" time (sec)
P_{out}	Output power (mW)
N_r	Number of times receiver is switched "on"
P_r	Power consumed by receiver (mW)
T_r	Start-up time for receiver (sec)
E	Energy (mJ)
t	Time (sec)

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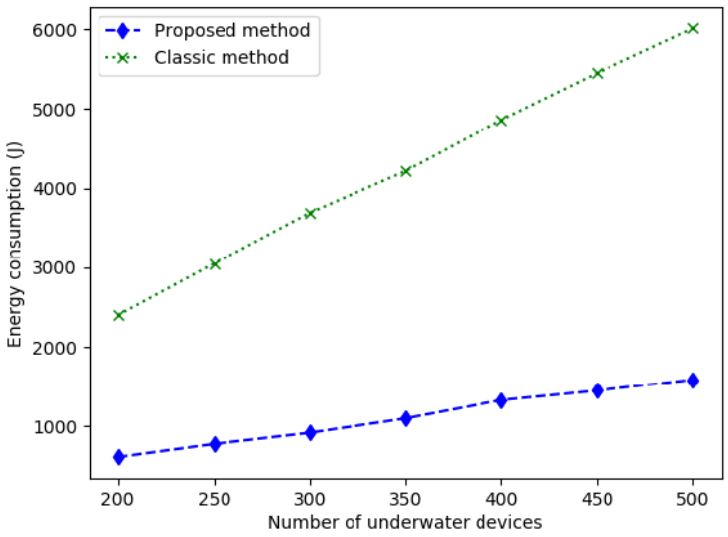
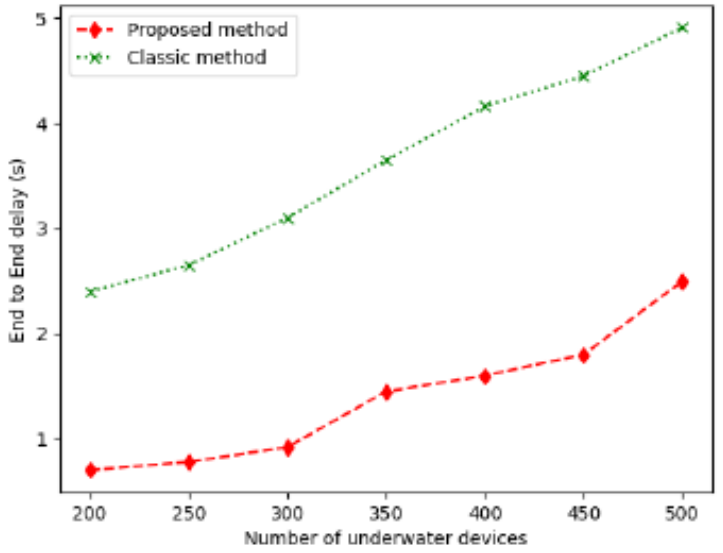


Average energy consumption in Simulated Scenario



End-to-End delay

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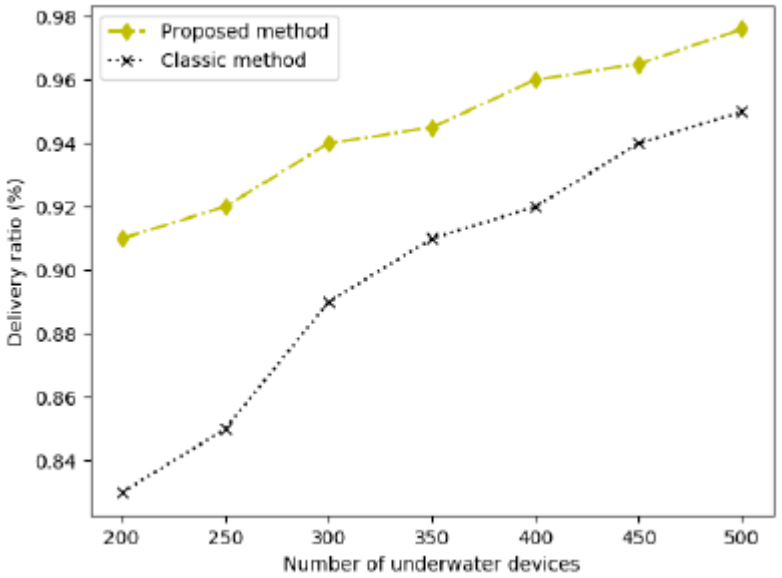
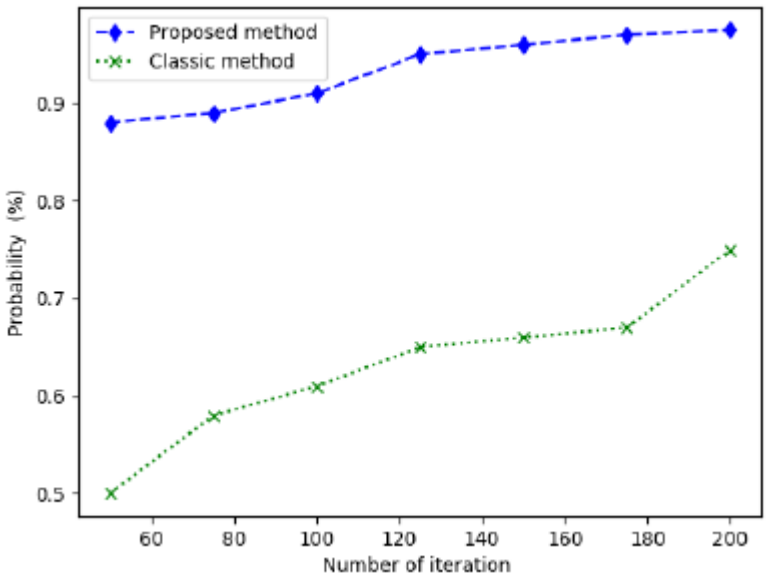


Packets delivered in Simulated Scenario



Authentication Attack Detection Probability

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Conclusion

- Our preliminary work shows the feasibility of integrating blockchain with IoUT
- For future work, exploring the use of SDN in the underwater environment and its impact on the authentication process. Plus, more evaluation on blockchain performance.

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Questions?

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