# Enabling Decentralized Identifiers and Verifiable Credentials for Constrained IoT Devices

Vasilios A. Siris

Mobile Multimedia Laboratory
Athens University of Economics and Business, Greece
vsiris@aueb.gr

EU H2020 SOFIE: Secure Open Federation for Internet Everywhere

# Contents

- Why constrained IoT (including intermittent or no connectivity) ?
- Authorization with constrained IoT devices
- What are Decentralized Identifiers (DIDs)?
- What are Verifiable Credentials (VCs)?
- Putting it all together: How and why to use DIDs & VCs for authorization in constrained IoT environments?

# Why constrained IoT environments?

- Because many IoT devices are constrained in terms of
  - processing and storage
  - network connectivity

} Reducing usage also ***reduces power consumption*** & ***security threats***

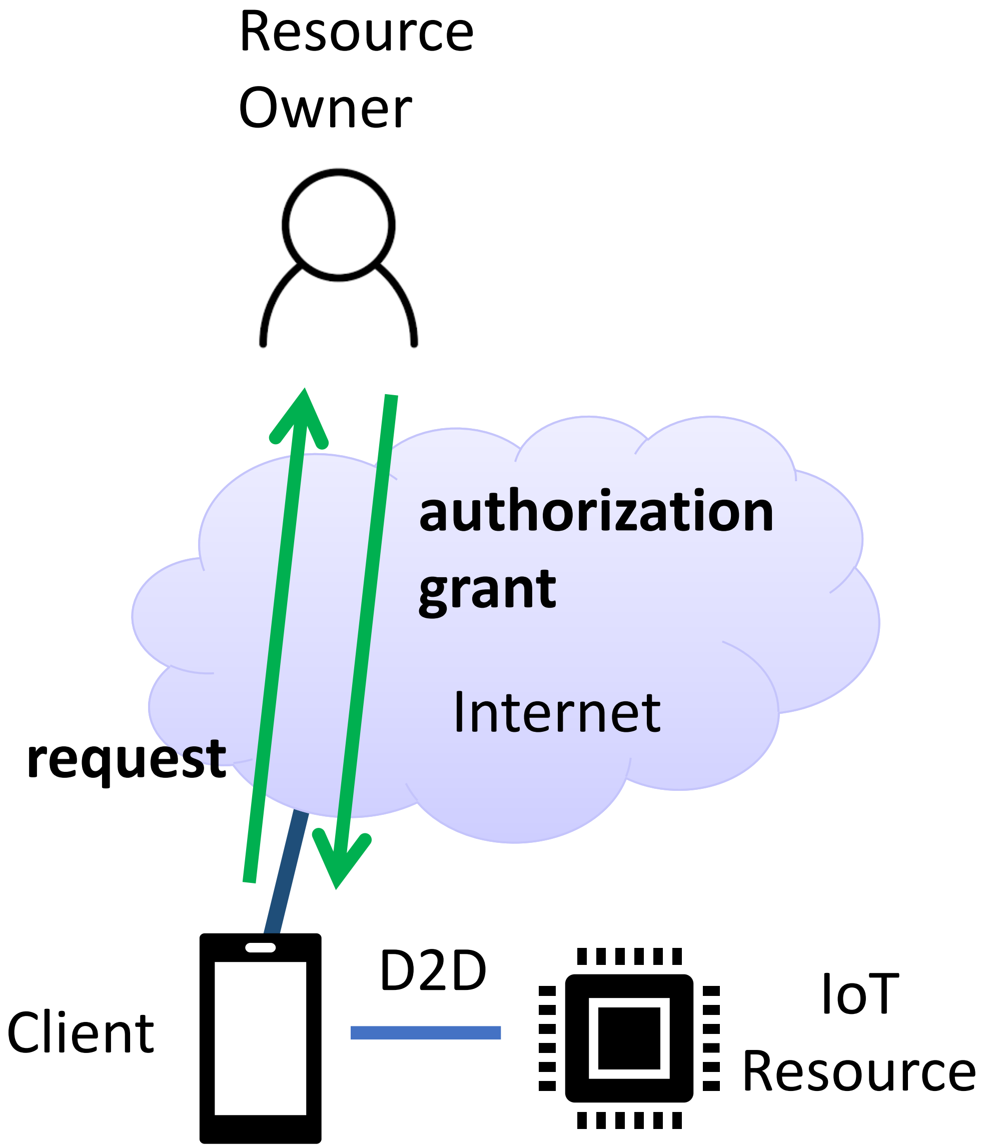
Scalability of IoT systems ***can be addressed*** by utilizing device-to-device & wireless multihop communication

Device-to-device technologies ***exist*** and are ***becoming more mature***

New challenge: how to achieve ***trusted*** device-to-device communication

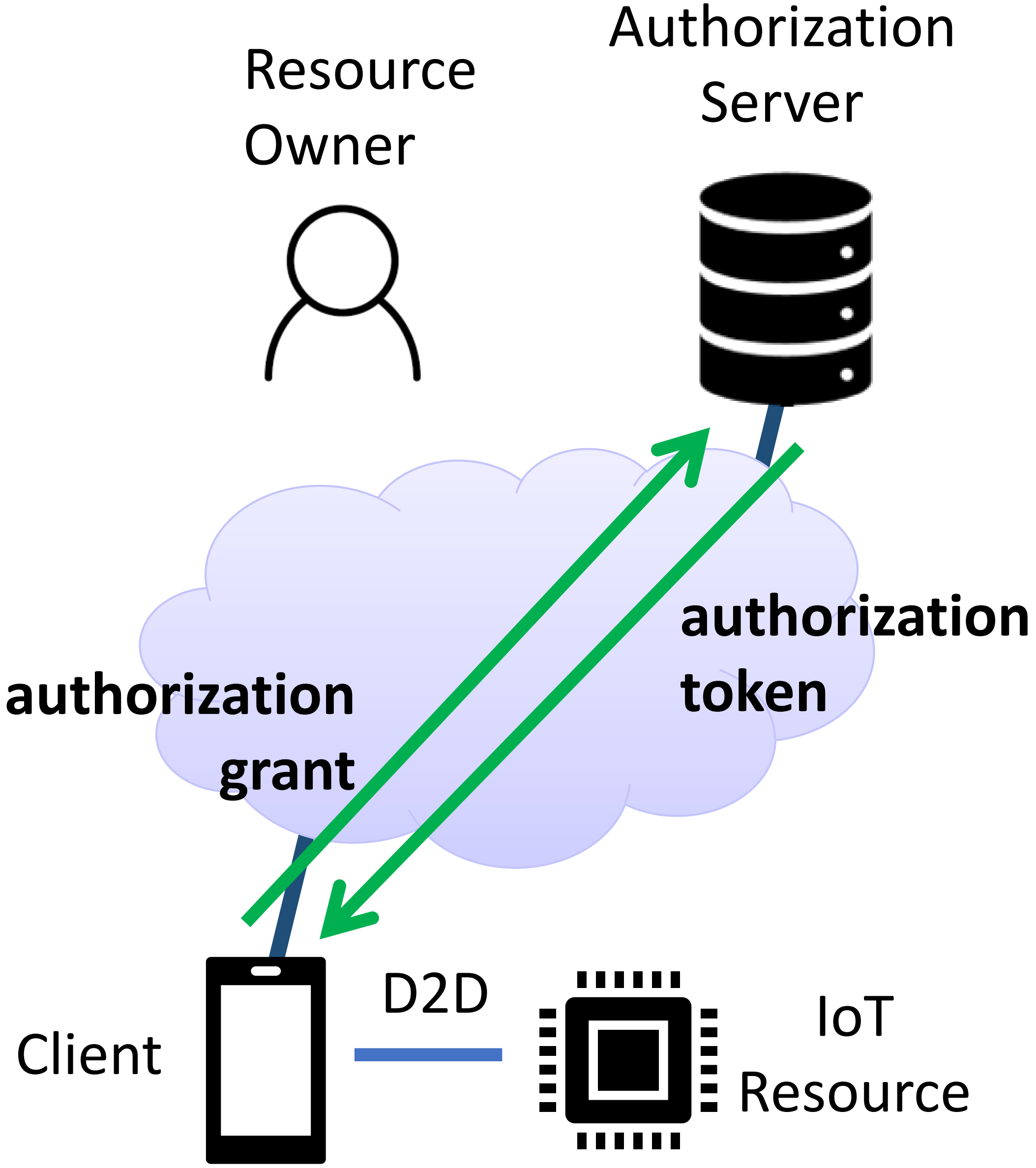
# Authorization for IoT resources

- Client seeks to access an IoT Resource which may be disconnected from the Internet



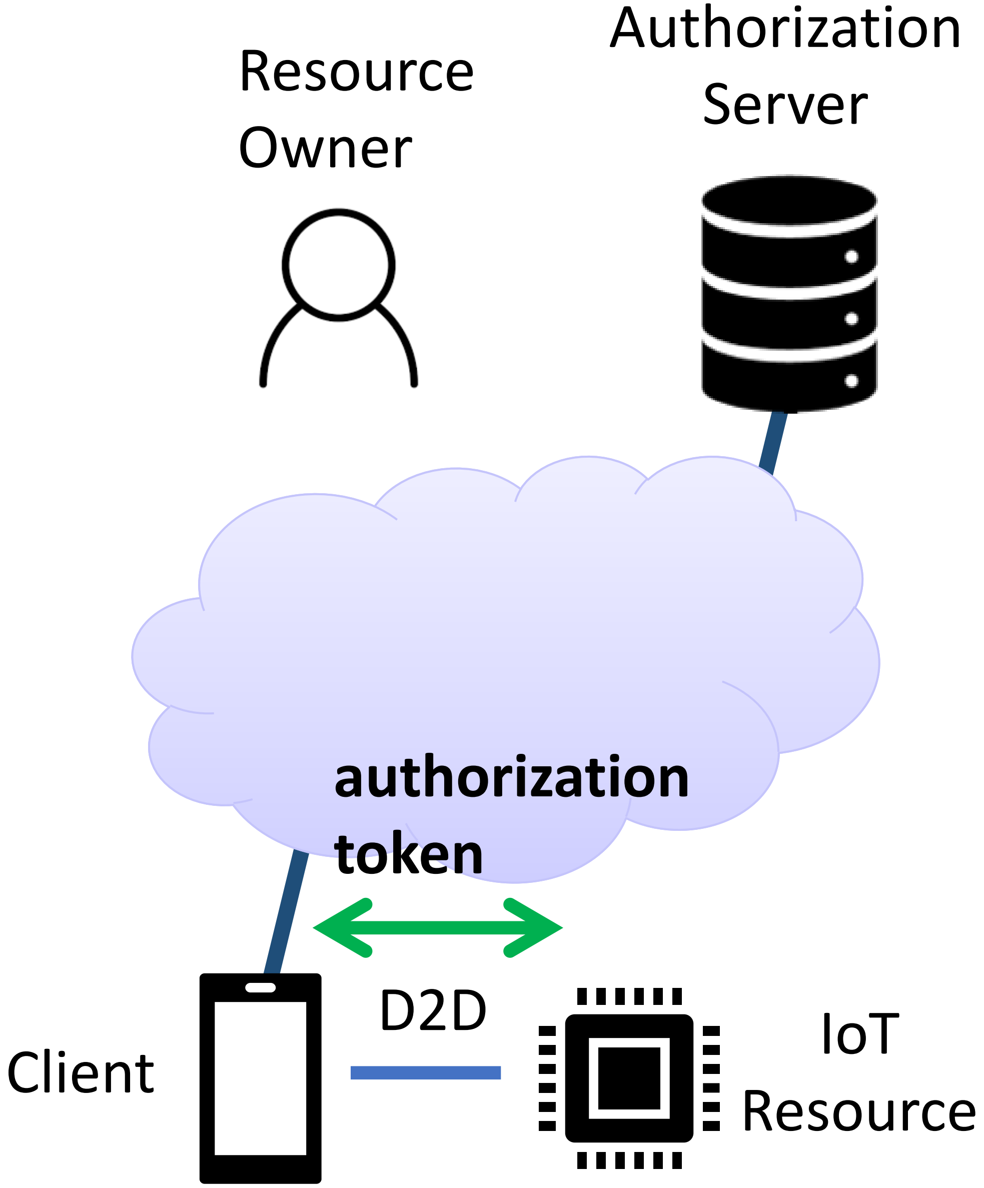
# SOFIE Authorization for IoT resources

- Client seeks to access an IoT Resource which may be disconnected from the Internet
- Authorization Server (AS) handles requests on behalf of IoT Resource
  - OAuth 2.0 authorization framework being developed by IETF's Authentication and Authorization for Constrained Environments (ACE) working group
  - Secure binding between AS-IoT Resource
  - Requires Resource Owner consent



# Authorization for IoT resources

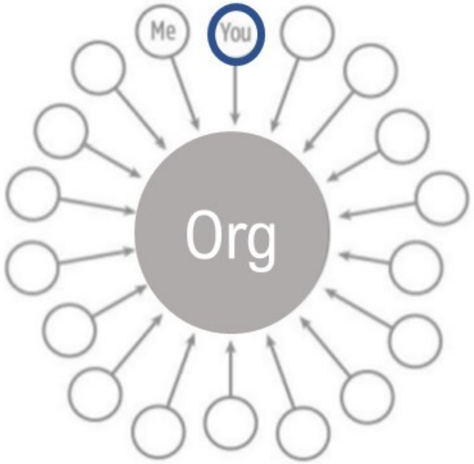
- Client seeks to access an IoT Resource which may be disconnected from the Internet
- Authorization Server (AS) handles requests on behalf of IoT Resource
  - OAuth 2.0 authorization framework being developed by IETF's Authentication and Authorization for Constrained Environments (ACE) working group
  - Secure binding between AS-IoT Resource
  - Requires Resource Owner consent
- Client accesses IoT Resource with authorization token



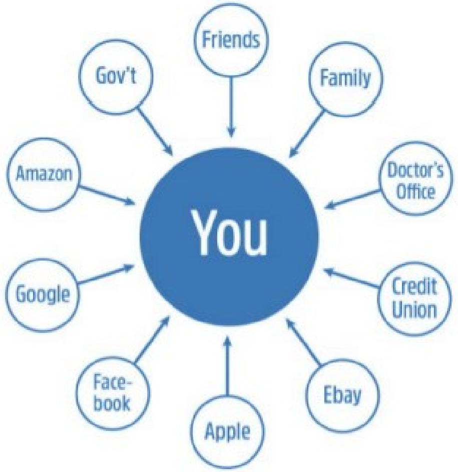
# What are Decentralized Identifiers

- Self-sovereign identifiers for individuals, organizations, things
- Persistent, dereference-able, cryptographically verifiable
- Registered in a blockchain, decentralized network, or off-ledger (ledger-agnostic)
- Standardized by W3C
- did:sov:3k9dg356wdcj5gf2k9bw8kfg7a

$$\underbrace{\text{did}}_{\text{Scheme}}:\underbrace{\text{sov}}_{\text{Method}}:\underbrace{\text{3k9dg356wdcj5gf2k9bw8kfg7a}}_{\text{Method-specific identifier}}$$



Organization in control of identity

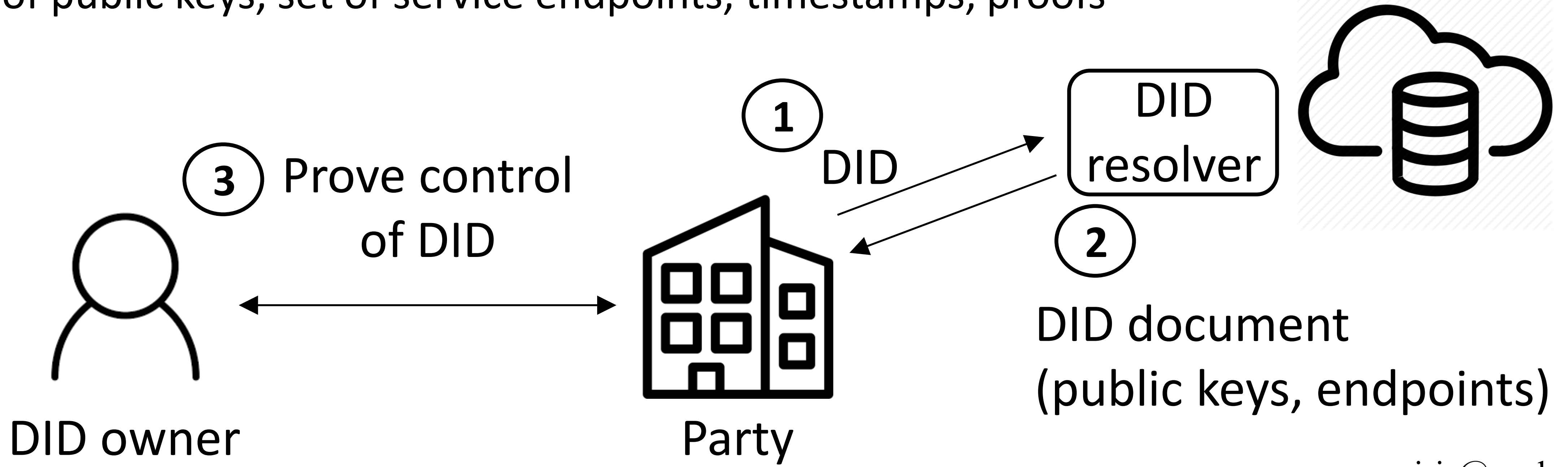


User in control of identity

# DID methods

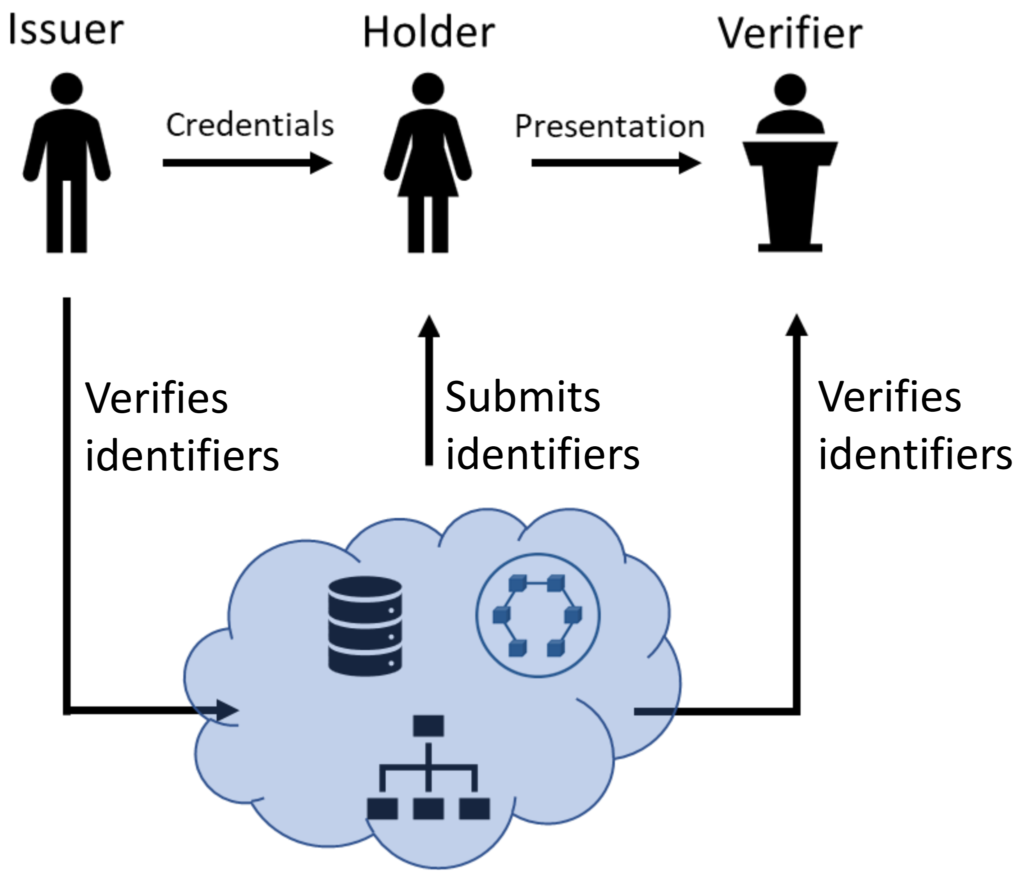
- Different DID methods  did:sov, did:btcr, did:v1, did:uport, ...
- CRUD for DIDs: Create, Read (Resolve), Update, Delete (Revoke)
- Resolution: DID → DID Document
  - Set of public keys, set of service endpoints, timestamps, proofs

Global database
(key, value)
(DID, DID Document)



# What are Verifiable Credentials (VCs)

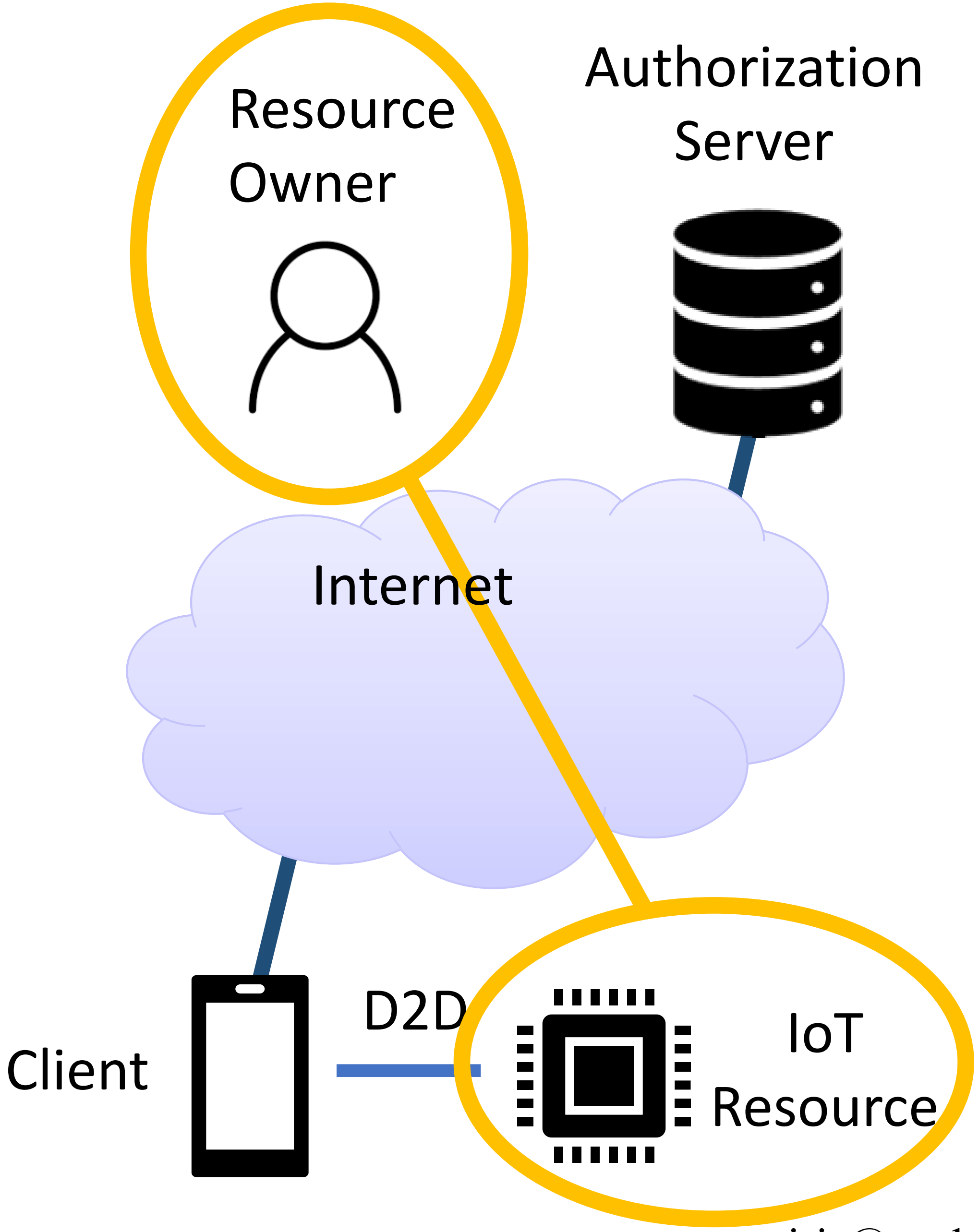
- Credential: A set of one or more claims
- W3C recommendation
- Requires framework for verifying identities
- Users (Holders) positioned between credential Issuers and Verifiers
- Users receive and store VCs from Issuers through an agent that can be untrusted
- Users provide VCs to Verifiers through an agent that can be untrusted
- VCs are associated with users and not particular services
- Users control which VCs to use and when
  - DIDs allow users to own & control their identifiers
- Users may freely choose agents to help them manage and share their VCs



Verifiable data registry
(maintains identifiers and schemas)

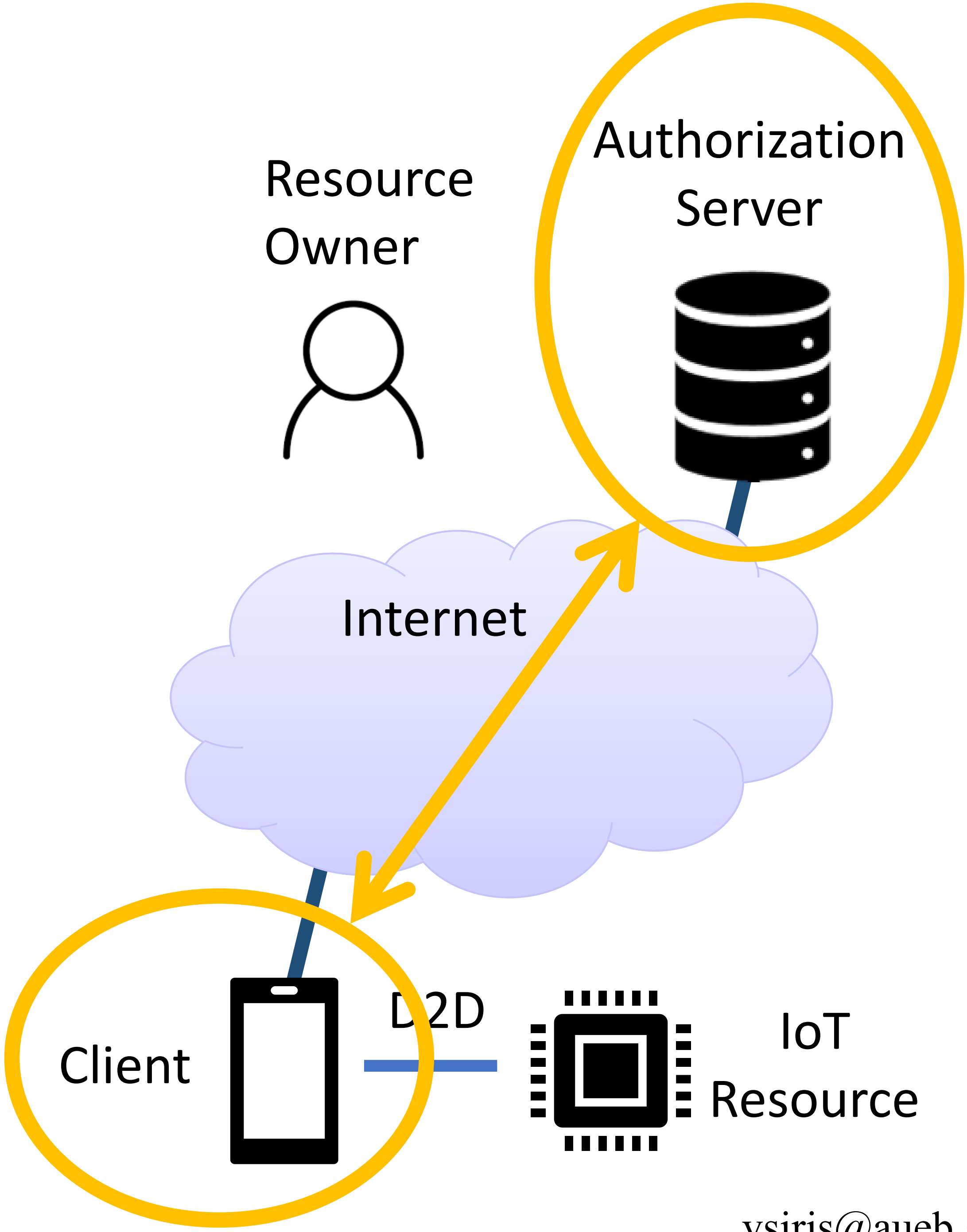
# Usage of DIDs

- DID for constrained IoT Resource
  - Used to bind IoT device to Resource Owner
  - Defines authentication method for Resource Owner (DID owner/controller)



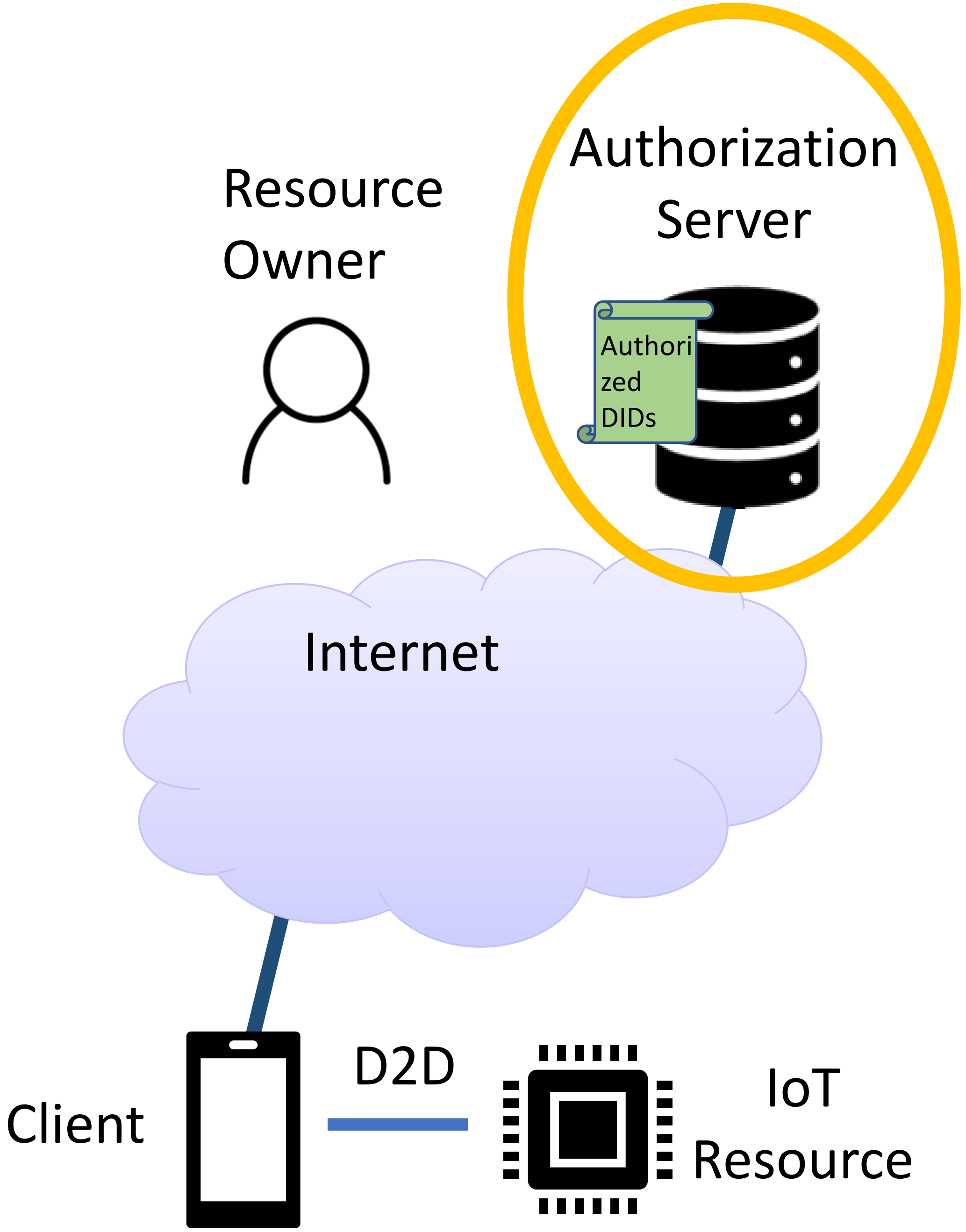
# Usage of DIDs

- DID for constrained IoT Resource
  - Used to bind IoT device to Resource Owner
  - Defines authentication method for Resource Owner (DID owner/controller)
- DID for Authorization Server: used for authenticating AS
- DID for Client: used for authenticating Client



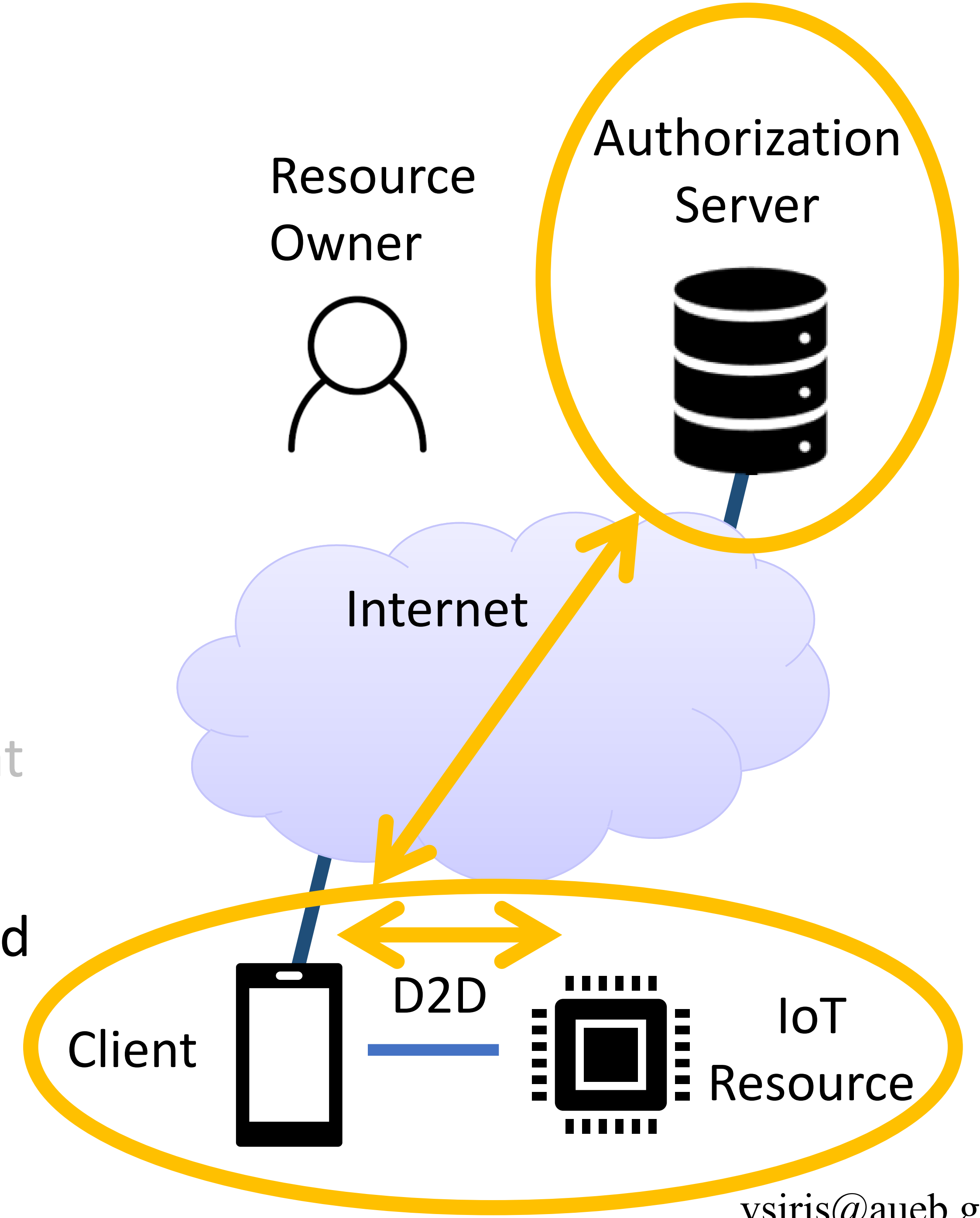
# Usage of DIDs

- DID for constrained IoT Resource
  - Used to bind IoT device to Resource Owner
  - Defines authentication method for Resource Owner (DID owner/controller)
- DID for Authorization Server: used for authenticating AS
- DID for Client: used for authenticating client
- DID of Client added to authorization list at AS
  - Resource Owner can be offline



# Usage of DIDs

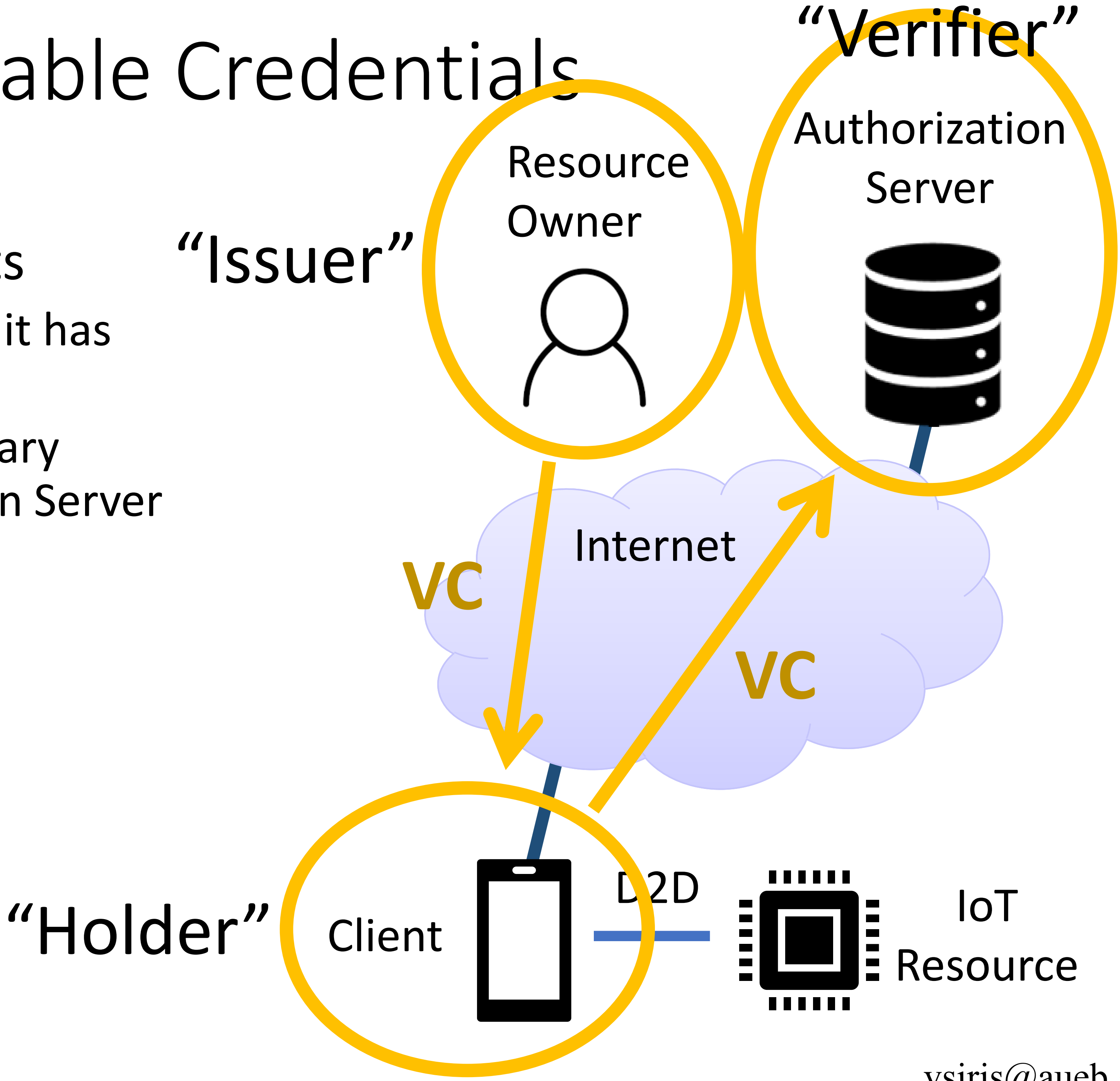
- DID for constrained IoT Resource
  - Used to bind IoT device to Resource Owner
  - Defines authentication method for Resource Owner (DID owner/controller)
- DID for Authorization Server: used for authenticating AS
- DID for Client: used for authenticating client
- DID of Client added to authorization list at AS
  - Resource Owner can be offline
- Multiple DIDs for IoT Resource, Client, and AS
  - pairwise unique for each transaction
  - act as pseudonyms → improved privacy



vsiris@aueb.gr

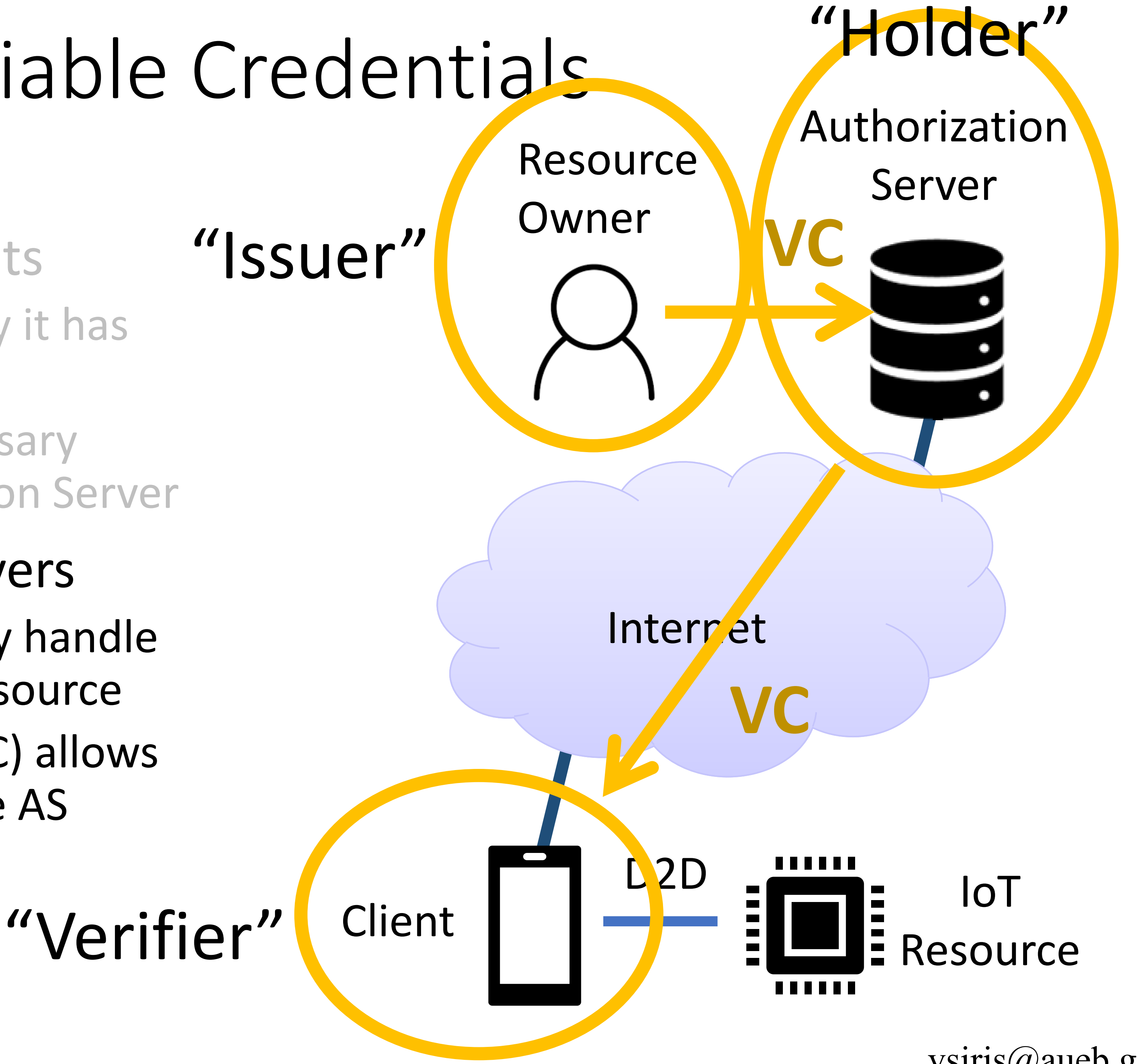
# Usage of Verifiable Credentials

- VCs for authorization grants
  - Required by Client to verify it has authorization
  - Client discloses only necessary information to Authorization Server



# Usage of Verifiable Credentials

- VCs for authorization grants
  - Required by Client to verify it has authorization
  - Client discloses only necessary information to Authorization Server
- VCs for Authorization Servers
  - Used by ASes to verify they handle authorization for an IoT resource
  - Revoking VC (or expired VC) allows Resource Owner to change AS



# Conclusion

- Why constrained IoT (including intermittent or no connectivity) ?
  - constrained CPU/storage, power efficiency, security, scalability
- Authorization with constrained IoT devices
  - IETF OAuth 2.0; both IoT Resources and Clients can be constrained devices
- What are Decentralized Identifiers (DIDs)?
  - Self-sovereign identifiers (for individuals, organizations, things) that are persistent, dereference-able, cryptographically verifiable
  - In contrast: Public Key Infrastructure (PKI) is a centralized trust infrastructure
- What are Verifiable Credentials (VCs)?
  - A set of one or more claims issued by an Issuer to a Holder that can be verified by a Verifier

# Conclusion (cont)

- Putting it all together: How and why to use DIDs & VCs for authorization in constrained IoT environments?
  - Bind IoT Resources to Resource Owners
  - Authenticate Authorization Servers (ASes) and Clients
  - Pairwise unique DIDs (Clients, IoT Resources, ASes) for each transaction
  - VCs for authorization grants (Resource Owner to Client) and for verifying ASes handling requests (Resource Owner to AS)

- All above in a **decentralized manner** with **users in control of their identities** and the **information disclosed**

Thank You!

# Enabling Decentralized Identifiers and Verifiable Credentials for Constrained IoT Devices

Vasilios A. Siris

Mobile Multimedia Laboratory
Athens University of Economics and Business, Greece
vsiris@aueb.gr

EU H2020 SOFIE: Secure Open Federation for Internet Everywhere

**Blockchain @ AUEB's MMlab:**
**https://mm.aueb.gr/blockchains/**

**SOFIE H2020 Project:**
**https://www.sofie-iot.eu/**