An SD-WAN Approach for EUt+ Network

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Outline

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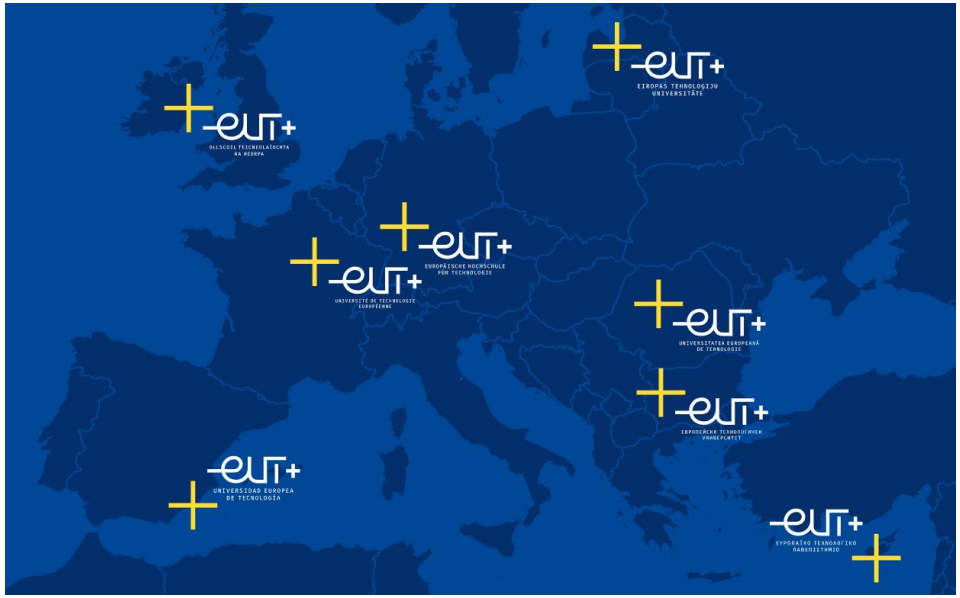
- Software-Defined Wide Area Network (SD-WAN)
- Management and Orchestration (MANO)
- Homomorphic Encryption
- Implementation
- Experimental Results
- Conclusions and Future Work

Introduction

- **European University of Technology (EUt+)**
  - 8 European universities
  - 100,000 students
  - Physical and virtual mobility
  - Recognized diploma and qualification for labor market
  - European Credit Transfer and Accumulation System

Introduction

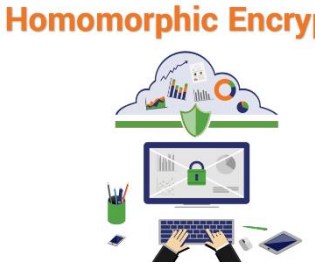
- **Framework**
  - Mobility
  - Quality of Experience
  - Data privacy



Introduction

- **Challenges**
  - Flexibility and scalability
  - Accessibility
  - Traffic engineering
  - Security

- **Solutions**
  - SD-WAN
  - MANO
  - Homomorphic encryption



SD-WAN

- **Goals**
  - Simplify networking operations
  - Optimize management and control
  - Enable better scalability and flexibility

- **Solutions**
  - B4 by Google, SWAN by Microsoft
  - ONOS, HyperFlow, Onix
  - OpenFlow, Payless

MANO

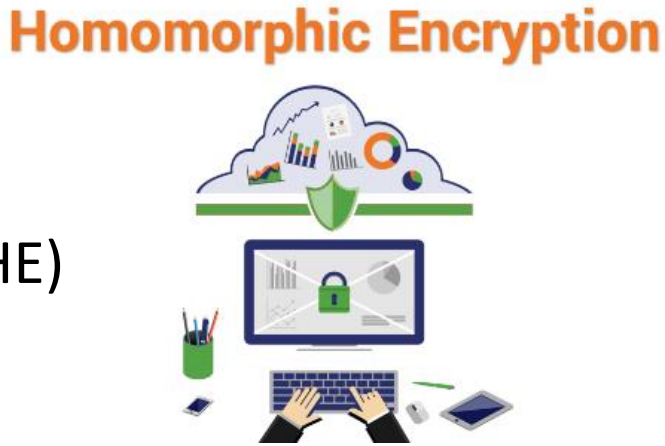
- **Network Functions Virtualization (NFV)**
  - Decouple the network functions from the hardware
  - Virtualized Network Functions (VNF)
  - Create, manage, scale and migrate VNFs
  - Management and Orchestration (MANO)

- **NFV MANO**
  - Framework proposed by the ETSI ISG NFV
  - Open Network Automation Platform
  - Open Source MANO

Homomorphic Encryption

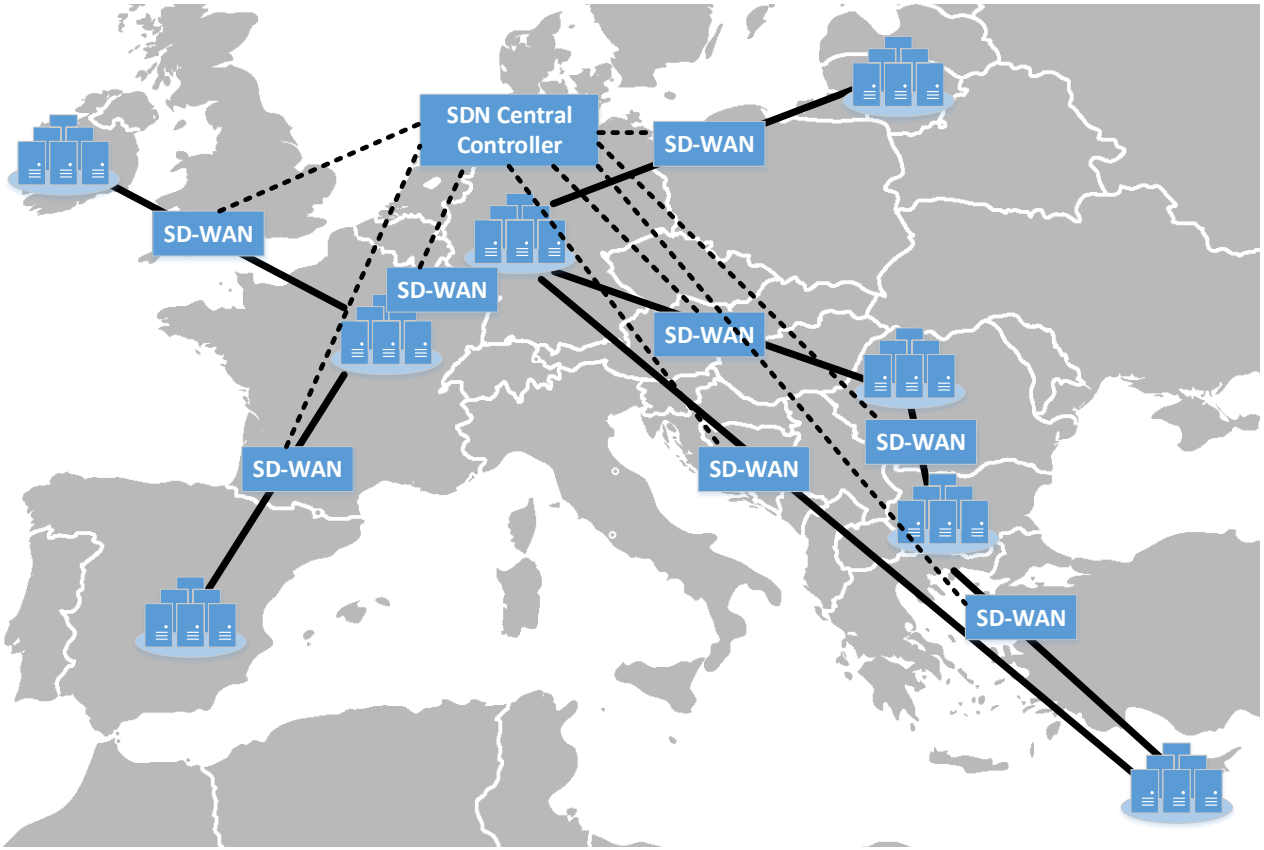
- **Legacy encryption techniques**
  - Processing on unencrypted data
  - Complex processing on the client side
  - Numerous data transfers = vulnerability to attacks

- **Homomorphic encryption**
  - Processing on encrypted data
  - Fully homomorphic encryption (FHE)
  - Practical in certain scenarios



Implementation

- **Proposed architecture**



Implementation

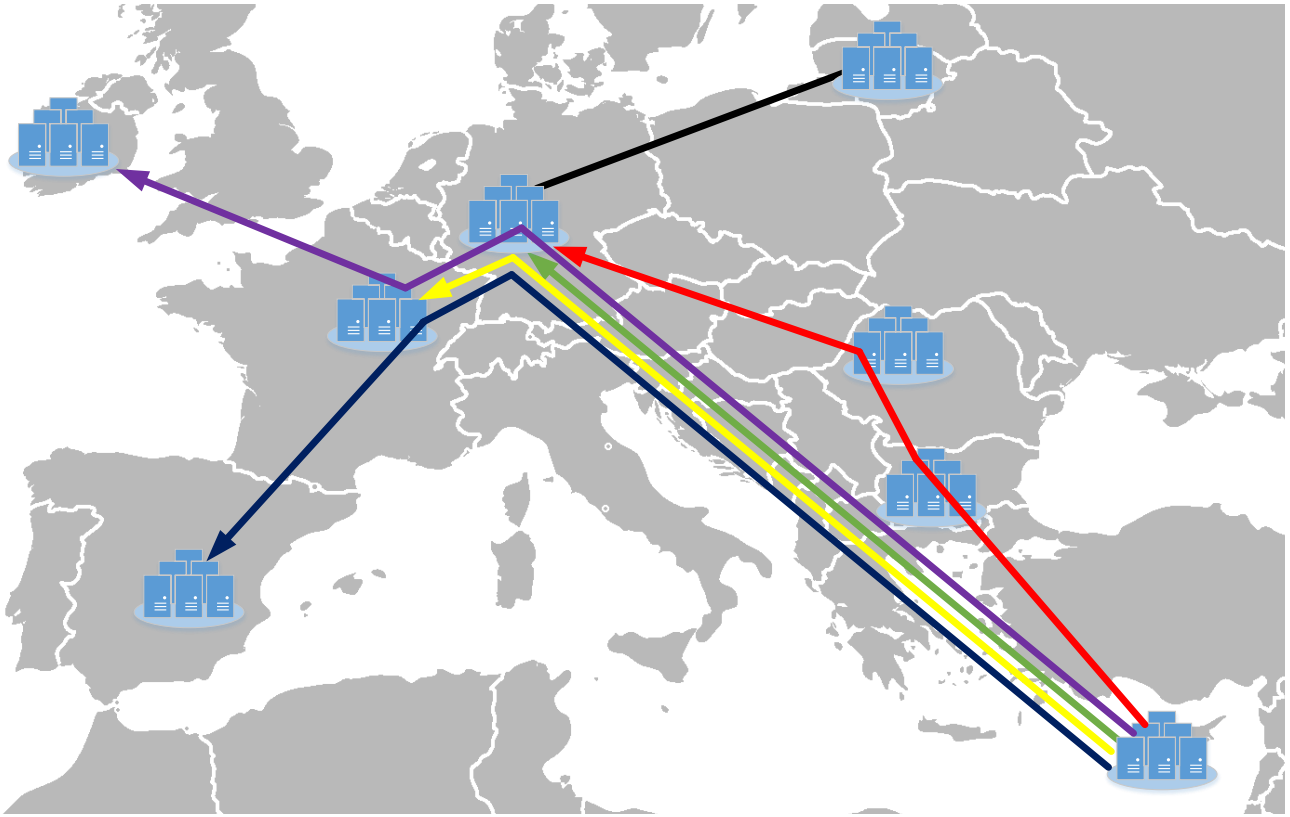
- **Network deployment and scalability**
  - Open^3++ software package
  - Multi-domain NS deployment
  - Orchestration-proxy daemon
  - Resource Orchestrator
  - Virtual Infrastructure Manager (VIM) – compute domain
  - WAN Infrastructure Manager (WIM) – network domain

Implementation

- **Network traffic management**
  - Two-layer mechanism
    - WIMs – decide how to use the resources on each link
    - Central SDN controller – finds the best path across the network
  - Monitored data
    - Link resources – ATR and OWD
    - Flow-related statistics
  - Quality of Experience
    - Traffic priority
    - Prediction
    - Real-time QoE feedback

Implementation

- **Network traffic management**



Implementation

- **Network security**
  - Secure data transfer
    - Legacy solution – TLS
  - Secure data storage
    - FHE – distributed database system
  - Processing on encrypted data
    - Personal records
    - Flow and link-related information
    - Prediction

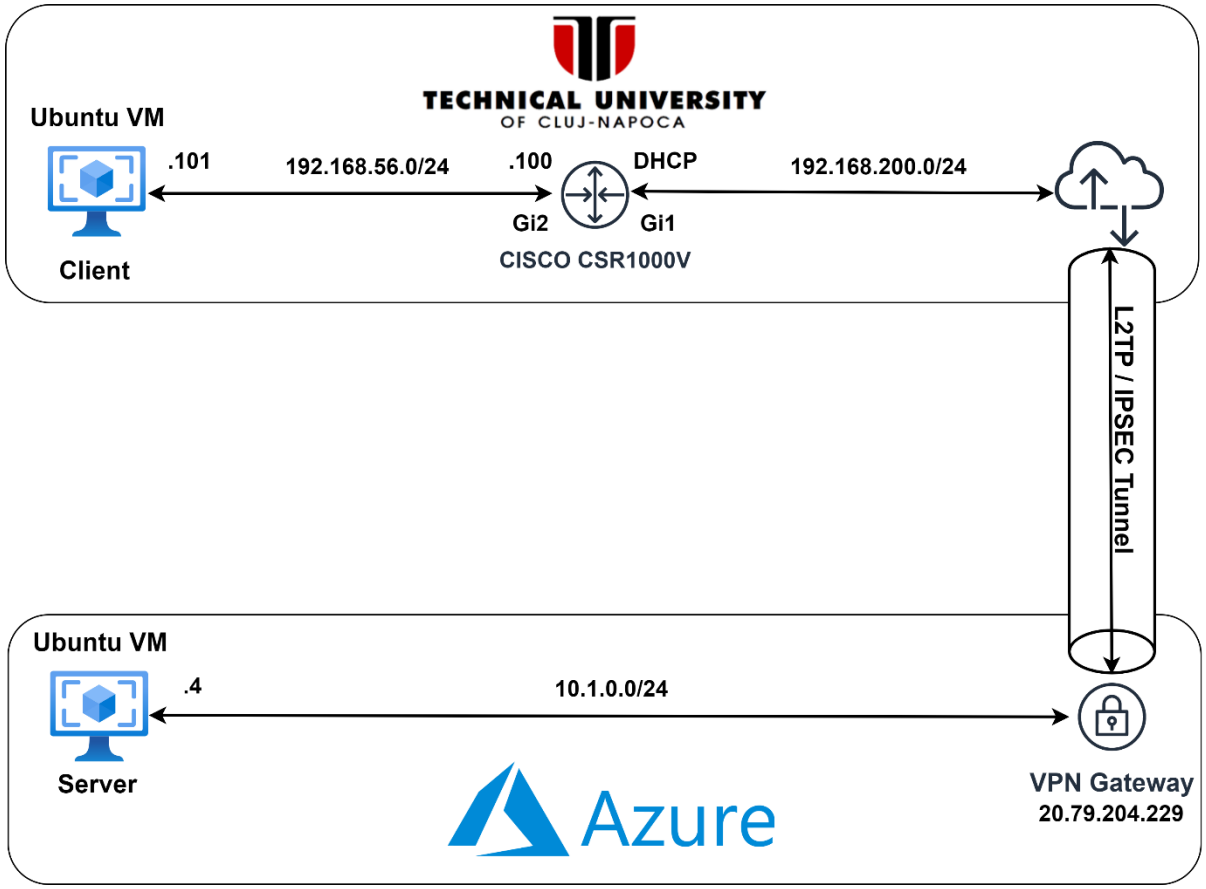
Experimental Results

- **Solution tested in the TUCN MAN**

University	Number of students
Technical University of Sofia (Bulgaria)	20,000
Cyprus University of Technology (Cyprus)	3,000
University of Technology of Troyes (France)	3,000
Hochschule Darmstadt - University of Applied Sciences (Germany)	15,000
Technological University Dublin (Ireland)	28,500
Riga Technical University (Latvia)	14,000
Technical University of Cluj-Napoca (Romania)	22,000
Polytechnic University of Cartagena (Spain)	6,500

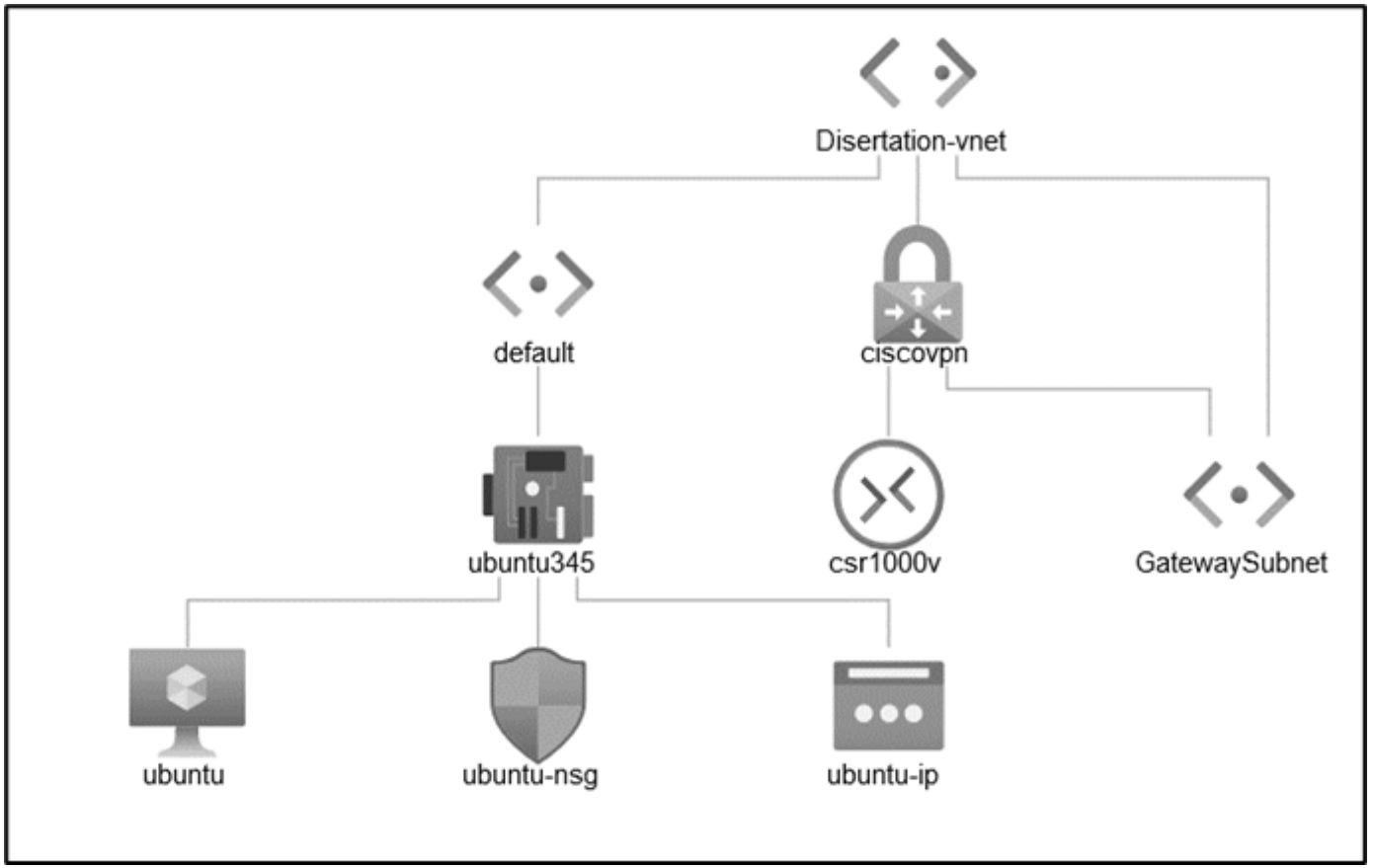
Experimental Results

- **Evaluate the SD-WAN proposed architecture**



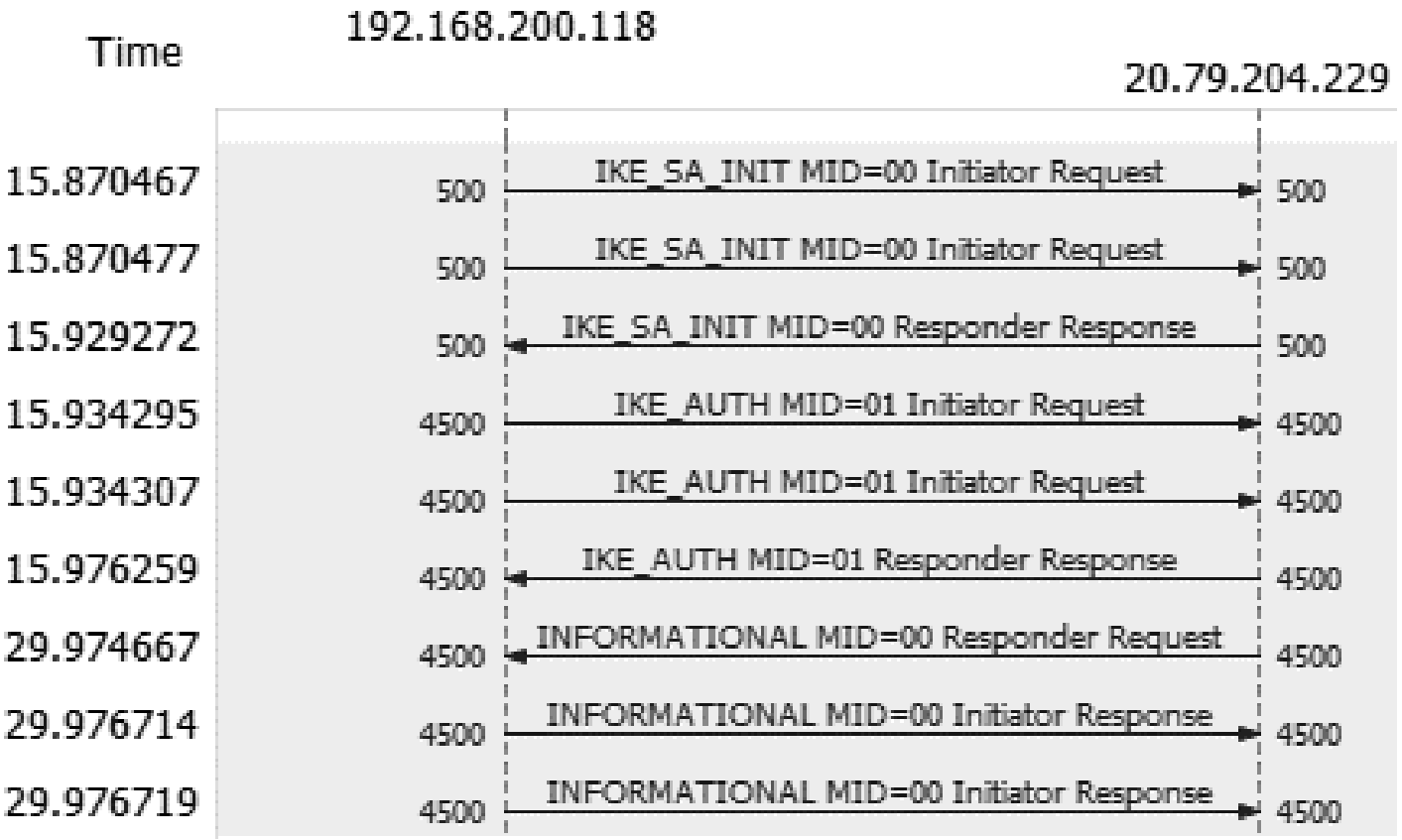
Experimental Results

- **Network topology in Azure**



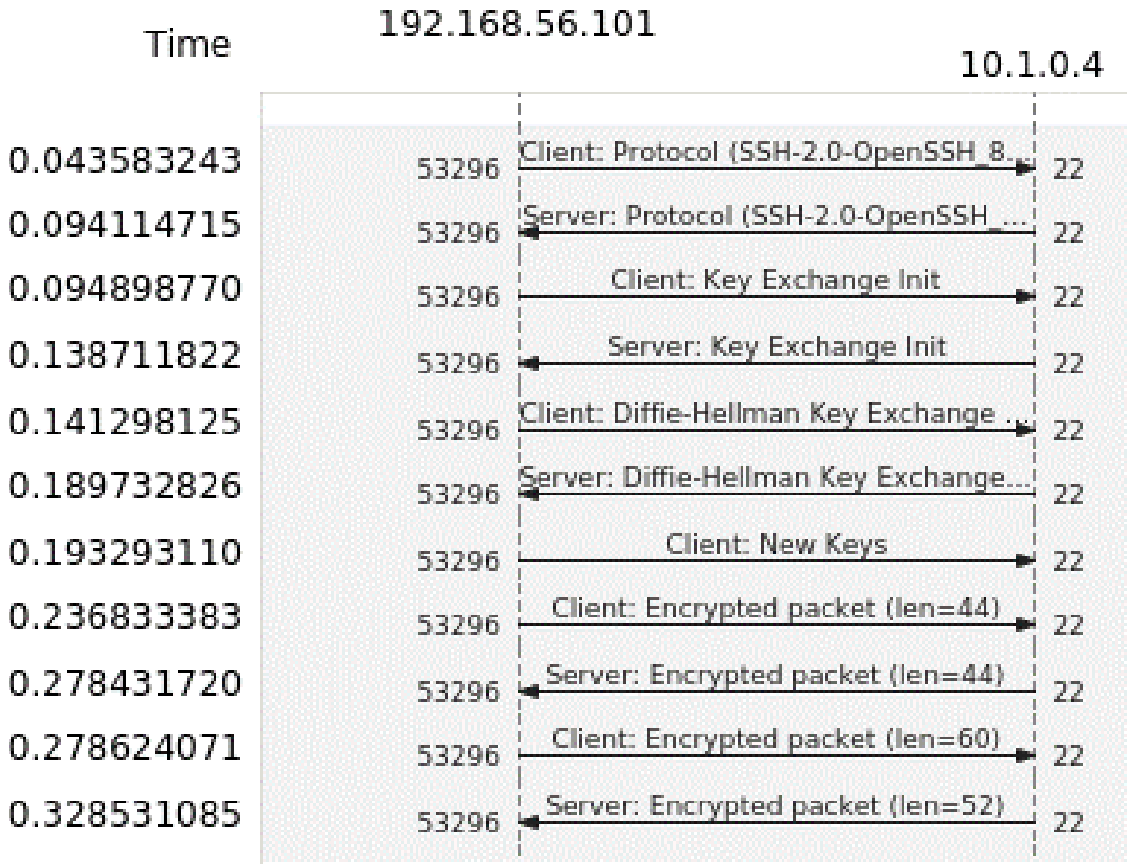
Experimental Results

- **IPSec tunnel creation**



Experimental Results

- **Client-server SSH connectivity**



Conclusions and Future Work

- **Conclusions**
  - Framework for EUt+
  - Physical and virtual mobility
  - Quality of Experience
  - Data privacy
  - Proof-of-work SD-WAN secure solution
- **Future work**
  - Include SD-WAN controller
  - Extend to multiple domains

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