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Communication Networks

Establishing a Session Database for SDN Using 802.1X and Multiple Authentication Resources

Joint Meeting of the VDE/ITG Sections 5.2.2 & 5.2.4

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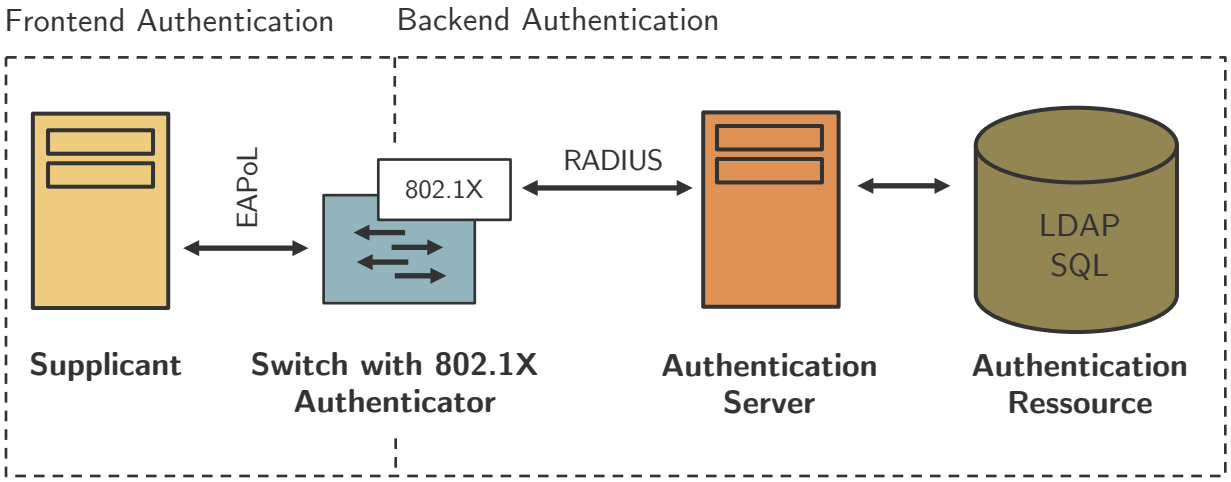
Motivation

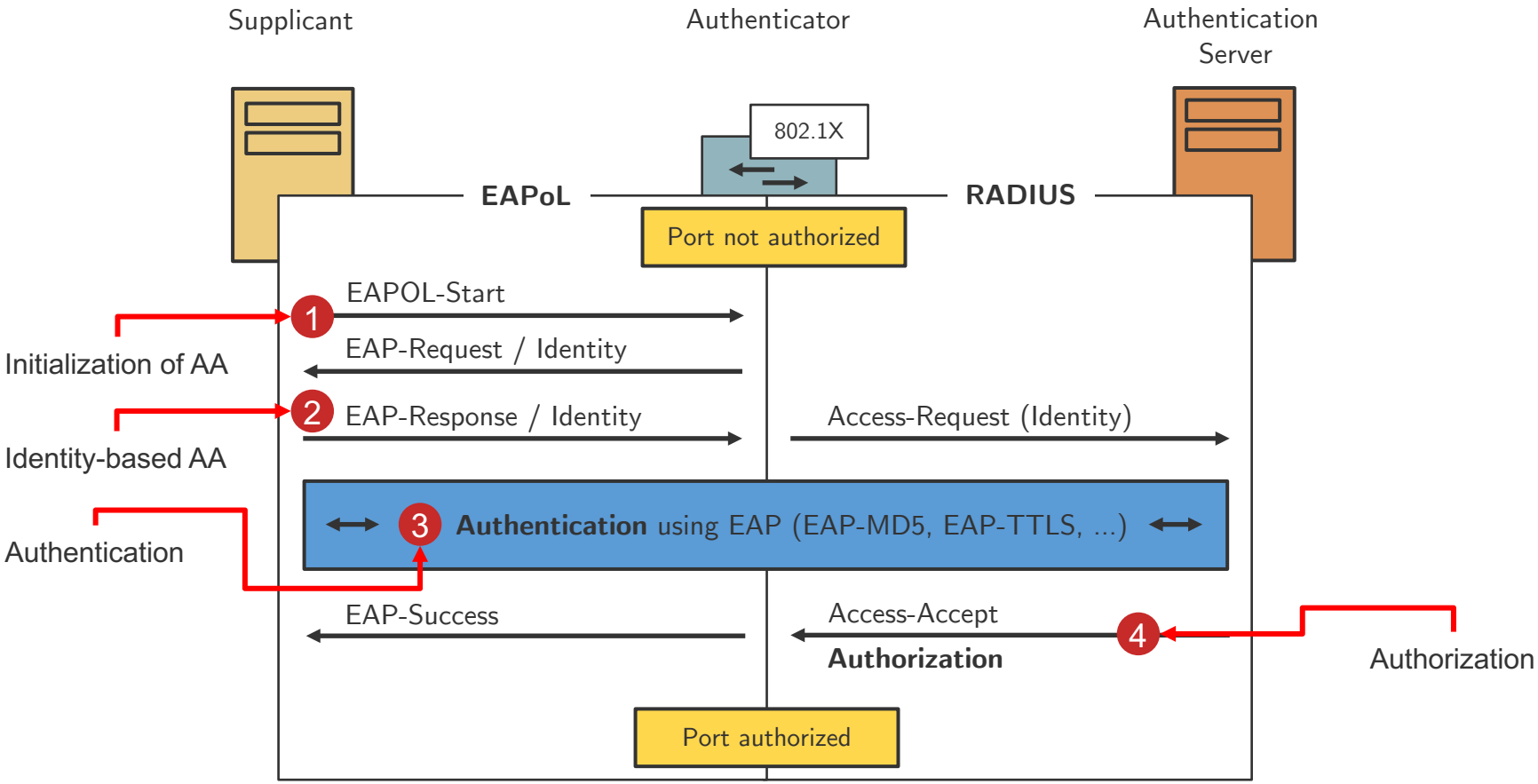
- Authentication and authorization (AA) as common mechanisms for securing communication networks
  - Status quo: coarse-granular access permissions
  - E.g., VLAN tagging, network admission rules, ...
- Extensive work on more fine-granular network control systems using software-defined networking (SDN)
  - Stateful and indentity-centric access permission rules
  - E.g., Ethane, Resonance, Kinetics, ...
  - Requires a network-wide session database and reliable authentication mechanisms
- Most widely used AA mechanisms in SDN
  - Static MAC-address-to-identity mapping
  - Web frontend authentication

802.1X

- Most widely used standard for port-based authentication and authorization in access networks (e.g., eduroam)
- Encompasses frontend and backend authentication
  - Frontend authentication: Extensible Authentication Protocol (EAP)
  - Backend authentication: Remote Dial-In User Service (RADIUS)



EAP and RADIUS in 802.1X



Limitations of 802.1X

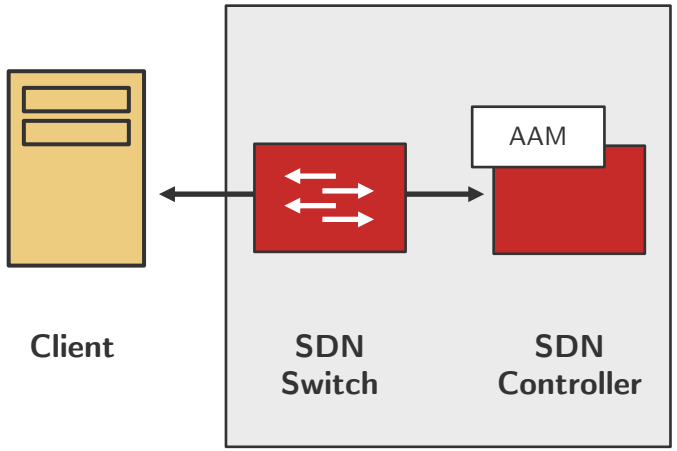
- Dependence on RADIUS or Diameter for backend AA
  - AA data is stored on external resources (e.g., SQL database)
  - Unnecessary overhead for specific setups
- Change of authorization
  - Backend AA does not support unsolicited messages, changes in authorization cannot be applied to existing sessions
    - Extension to RADIUS specified in RFC 5176, but hardly implemented
- Stateless property of RADIUS
  - Unlimited number of concurrent authorized network access by using one credential
    - Simultaneous-Use extension, but hardly deployed
    - Session management by little standardized RADIUS accounting messages, SNMP, Finger or telnet

Related Work

- Usage of hostapd (FAUCET, AuthFlow, FlowIdentity, …)
  - EAP packets are forwarded to an instance of hostapd (user-space 802.1X authenticator)
  - Channel between the SDN controller and hostapd to report successful authentication attempts
- Protocol extensions to 802.1X (FlowNAC)
  - EAPOL-in-EAPOL encapsulations for authentication and authorization of different applications running on a network host
  - Requires changes of all 802.1X components

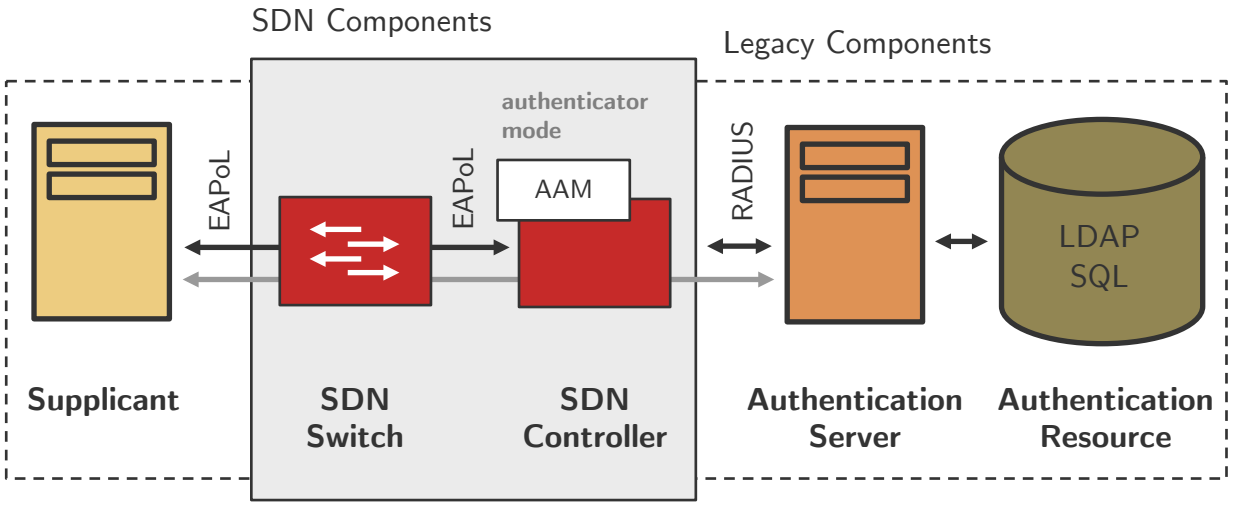
Objectives of this Work

- Use 802.1X for authentication and authorization in SDN
  - Compliance to standards (no modification on network endhosts or RADIUS-based AA infrastructure required)
  - Solve major shortcomings of current 802.1X infrastructures
- Architectural approach
  - AA module (AAM) serving as application for an SDN controller
    - Legacy 802.1X authenticator (authenticator mode)
    - Alternate AA resources (authentication server mode)
  - Session database



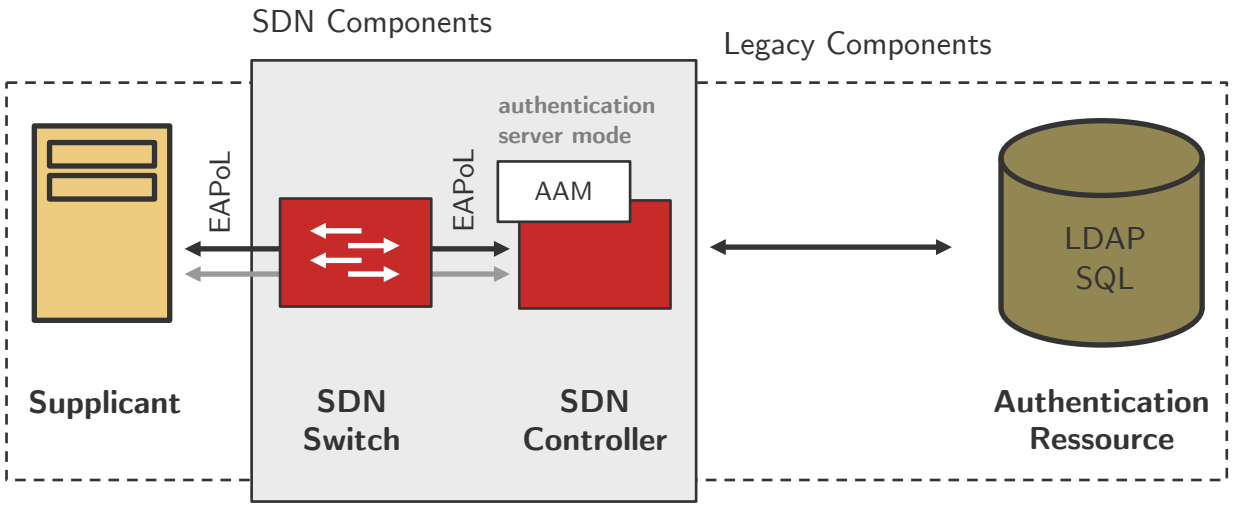
Authenticator Mode

- **Authenticator mode**
  - AAM adopts the functionality of a legacy 802.1X authenticator
  - No need for implementing specific EAP types (e.g., EAP-TLS, …)
  - AAM implements mechanisms to translate authorization data (e.g., a VLAN tag) into corresponding SDN rules
  - Scenario: use an existing RADIUS infrastructure for AA in SDN



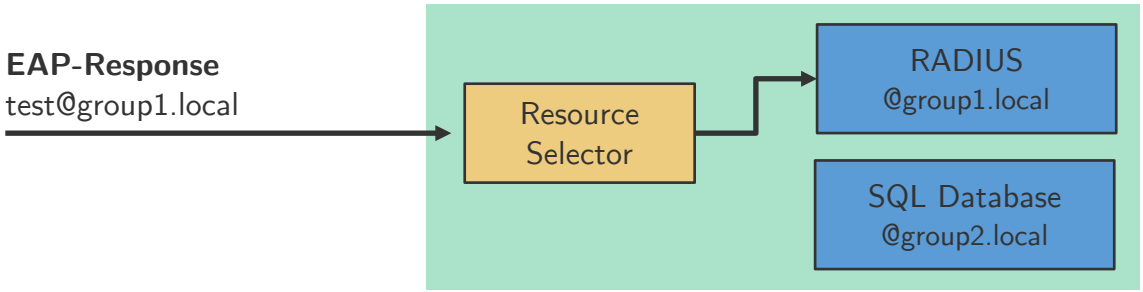
Authentication Server Mode (1/2)

- Integrating alternative AA resources: **Authentication server mode**
  - AAM acts as authenticator and authentication server
    - Implementation of EAP type specifics required
    - Implementation of AA resource interfacing required
  - Scenario: use AA resources (e.g., a SQL database or an LDAP server) for AA in SDN



Authentication Server Mode (2/2)

- Choosing between authenticator and authentication server mode and different AA resources
  - Port-based selection
    - AA resource is selected using the switch port identifier
  - Identity-based selection
    - AA resource selection according to the EAP (outer) identity



Network-Wide Session Database

- Session database contains information about all authenticated and authorized identities
- AAM triggers actions on the session database
  - Session removal (e.g., in case of a port down event)
  - Reauthentication
- External applications can interact with the AAM by using communication techniques like REST interfaces

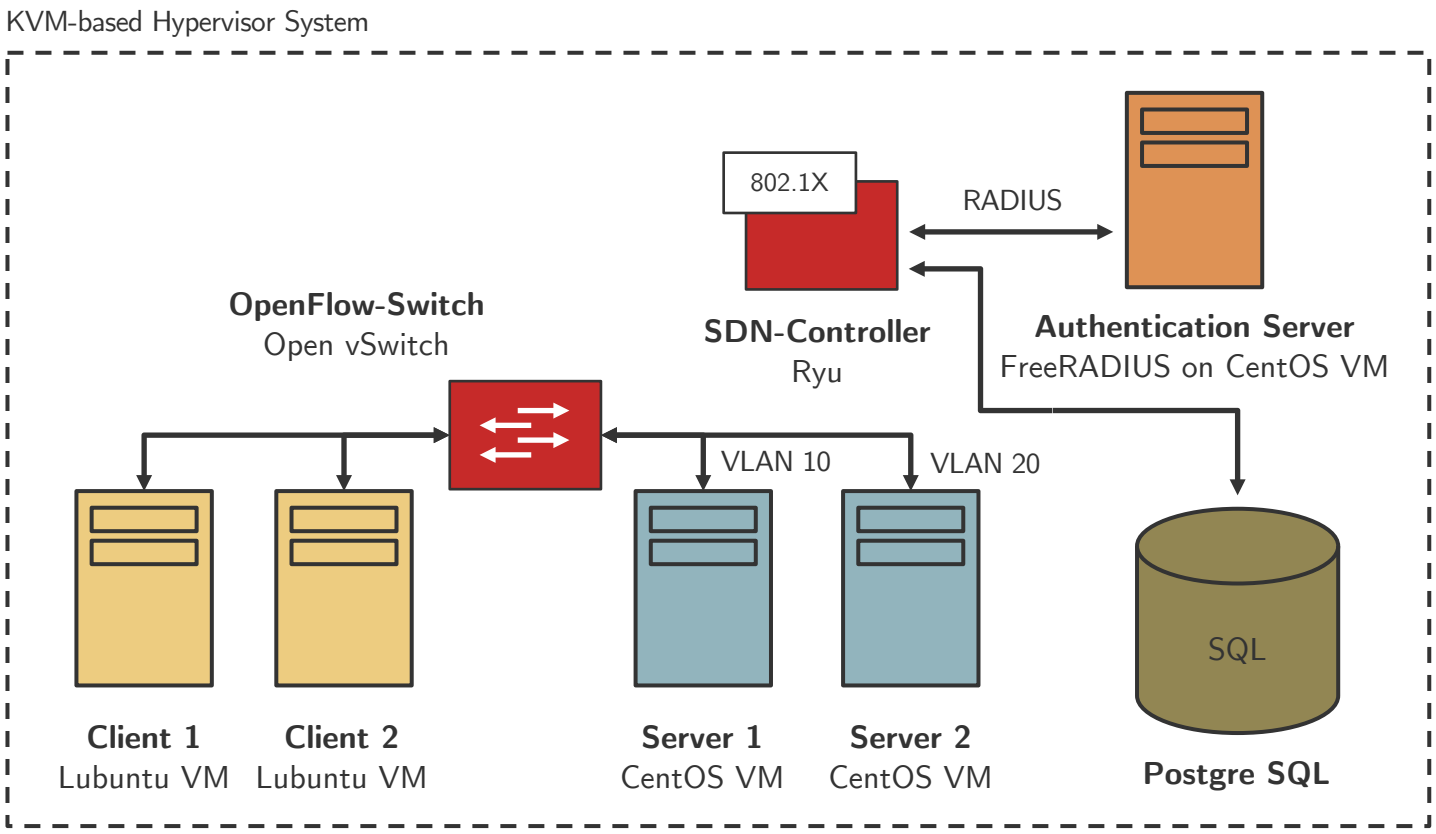
```
{ test@group1.local : { max_sessions : 1, sessions : (
            { aaa_time : Mo 13 Jun 2016 14:16:26 CEST,
              aaa_method : Radius(ip=10.0.20.100, meth=EAP-MD5),
              phys_port : OF-Switch(ip=10.0.20.222, port=1),
              assigned_vlans : (10)},
            { aaa_time : Mo 13 Jun 2016 14:18:31 CEST,
              aaa_method : Radius(ip=10.0.20.100, meth=EAP-MD5),
              phys_port : OF-Switch(ip=10.0.20.222, port=2),
              assigned_vlans : (10)},
            )}
}
```

Prototypical Implementation & Functional Validation (1/2)

- Prototypical implementation for the Ryu SDN controller framework
  - Python-based 802.1X authenticator implementation
    - Extension of *dpkt* (network packet generation and parsing) by RADIUS and EAP protocol handlers
- Testbed
  - OpenFlow switches
    - Hardware-based OpenFlow switches
      - HP Enterprise 2920 (firmware version 16.01.0006)
        100% EAPoL frame droppings (incompatibility issue)
      - Zodiac FX (firmware version 0.66)
        Expected behaviour
    - Software-based OpenFlow switches
      - Open vSwitch (version 2.4.0)
        Expected behaviour
  - KVM-/QEMU-based virtual machines

Prototypical Implementation & Functional Validation (2/2)

- Various tests within a functional validation scenario
  - E.g. usage of multiple AA ressources, session database, …



Outlook & Conclusion

- Outlook: Scalability of the AAM
  - AAM load highly dependent on the mode of operation (authenticator or authentication server mode)
  - Approach: deploy the AAM as network function
    - AA processes are independent and can be parallelized
    - SDN controller installs flow rules for EAPoL frame forwarding to particular AAM instances that interact with the network-wide session database
- Conclusion
  - Proposition to adopt 802.1X for authentication and authorization in SDN with multiple AA resources and a network-wide session database
  - Design and prototypical implementation of the AA module (AAM) for running within the Ryu SDN controller framework