Wireless and Wired Bridging using Vlan.

(A case study at Electrical Engineering UBAYA).
Topics of Discussion

• Virtual LAN (VLAN)
• Wired and Wireless Trunk System (Bridge, WDS, Repeater, Tunnel)
• Implementation Vlan @ EE Ubaya
  • Discussion
About Me
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- I have learn and teach in Department of Electrical Engineering (EE) and IT since 1986.
- MikroTik Academy Trainer for EUTC with certifications: MTCNA, MTCRE, MTCWE, MTCTCE and MTCINE
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Universitas Surabaya (Ubaya)
Objective

- To help you understand fundamental of Virtual Local Area Network (VLAN) and implementation in MikroTik router
- To explain a few example of implementation of Vlan in Wireless dan Wired Trunk
- To show the implementation VLAN in Electrical Engineering (EE) - Ubaya
VLAN (Virtual LAN)

- VLAN is a Layer 2 method that allows multiple Virtual LANs on a single physical interface.
- You can also transport VLANs over wired and wireless links and put multiple VLAN interfaces on a single wireless interface.
Each VLAN is **treated as a separate subnet.** It means that by default, a host in a specific VLAN cannot communicate with a host that is a member of another VLAN, although they are connected in the same switch.
Why VLAN?

- We can create multiple LAN in a single physical interface, so we will have multiple broadcast domain in a single physical interface.
- We can manage the local network more simple and manage the different network in one single interface.
- We can create multiple vlan-id in one interface (Trunk) OR multiple interface for one vlan-id (Access).
IEEE 802.1Q

- IEEE 802.1Q is a standardized encapsulation protocol that defines how to insert (tagged) a four-byte VLAN identifier into Ethernet header.
- RouterOS supports up to 4095 VLAN interfaces, each with a unique VLAN ID, per interface (exception: 0, 1 and 4095)
IEEE 802.1Q

Tagged

Untagged

Ether Type: 0x0800 (IP4), 0x8100 (802.1Q)
VLAN Access and Trunk

A trunk **carries Tagged** packets between switches and/or router.

**TRUNK** (VLAN 10, VLAN 20, VLAN 30)

Access **carries Untagged** packets to end devices or host (PC, laptop, Servers, etc)

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VLAN Access and Trunk

Tagged VLAN ID

TRUNK (VLAN 10, VLAN 20, VLAN 30)

VLAN 10  20   30
VLAN 10  20   30
VLAN 10  20   30

ACCESS             ACCESS              ACCESS

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VLAN Access and Trunk

TRUNK (VLAN 10, VLAN 20, VLAN 30)

Untagged Vlan ID
Tagged and Untagged Vlan ID

- **Vlan ID:** Tagged on Trunk, then Untagged on Access
How to VLAN?

1. Create bridges for **Trunk** and bridges for each **Access**

2. Add **Interfaces VLAN on the Trunk Bridge** and put ethernet (tagged) port into **Trunk Bridge Port**

3. Add **untagged vlan interface and ethernet (untagged) ports** into **Access Bridges Port**.
1) Create Bridges

Create bridges for **Trunk** and bridges for **each Access**

```
/interface bridge
add fast-forward=no name=bridge-trunk
add fast-forward=no name=bridge-vlan200
add fast-forward=no name=bridge-vlan300
add fast-forward=no name=bridge-vlan400
```
2) Create VLAN @BridgeTrk

Add Interfaces VLAN on the Trunk Bridge and put ethernet (tagged) port into Trunk Bridge Port

```
//interface vlan
add interface=bridge-trunk name=eth2-vlan200 vlan-id=200
add interface=bridge-trunk name=eth2-vlan300 vlan-id=300
add interface=bridge-trunk name=eth2-vlan400 vlan-id=400

//interface bridge port
add bridge=bridge-trunk interface=ether2
```
3) Untagged VLAN @BridgeAcc

Add untagged vlan interface and ethernet (untagged) ports into Access Bridges Port.

```
/interface bridge port
add bridge=bridge-vlan200 interface=eth2-vlan200
add bridge=bridge-vlan200 interface=ether6
add bridge=bridge-vlan300 interface=eth2-vlan300
add bridge=bridge-vlan300 interface=ether7
add bridge=bridge-vlan400 interface=eth2-vlan400
add bridge=bridge-vlan400 interface=ether8
```
Bridge VLAN Filtering
(since RouterOS 6.41 AND support Hardware Offload)

1. Create a bridge with disabled vlan-filtering (no)
2. Add Bridge Ports and specify PVID for VLAN access ports to assign their untagged traffic to the intended VLAN.
3. Add Bridge VLAN entries and specify tagged and untagged ports in them.
4. In the end, when VLAN configuration is complete, enable vlan-filtering.

Bridge VLAN Filtering

/interfac3e bridge
add name=bridge1 vlan-filtering=no

/interfac3e bridge port
add bridge=bridge1 interface=ether2
add bridge=bridge1 interface=ether6 pv3d=200
add bridge=bridge1 interface=ether7 pv3d=300
add bridge=bridge1 interface=ether8 pv3d=400

/interfac3e bridge vlan
add bridge=bridge1 tagged=ether2 untagged=ether6 vlan-ids=200
add bridge=bridge1 tagged=ether2 untagged=ether7 vlan-ids=300
add bridge=bridge1 tagged=ether2 untagged=ether8 vlan-ids=400

/interfac3e bridge set bridge1 vlan-filtering=yes

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Reading Suggestion

- Youtube: https://www.youtube.com/watch?v=ZM Mpza-O7_w (VLAN processing in New bridge implementation by: Andis Arins, April 2018)
Hybrid VLAN Ports

- An Hybrid Vlan port is a special mode that allow untagged and tagged packets on the same port.

```
/interface bridge vlan
add bridge=bridge1 tagged=ether2,ether7,ether8 untagged=ether6 vlan-ids=200
add bridge=bridge1 tagged=ether2,ether6,ether8 untagged=ether7 vlan-ids=300
add bridge=bridge1 tagged=ether2,ether6,ether7 untagged=ether8 vlan-ids=400
```
Inter VLAN Routing

- Routing process between VLANs is called Inter-VLAN Routing. Communication between VLAN must be Routed.
- Configure VLAN interfaces on the bridge1 to allow handling of tagged VLAN traffic at routing level.
Wired Trunk

WIRED TRUNK:
Ether 1: Vlan ID 110,120,130

ACCESS PORTS Vlan:
Wlan 1:
110: 192.168.110.0/24
Ether 2:
120: 192.168.120.0/24
Ether 3-5:
130: 192.168.130.0/24
Wireless Trunk

WIRELESS TRUNK:
Wlan1 : VLan 110,120,130:
192.168.100.0/24

ACCESS PORTS Vlan:
Ether 1:
110:  192.168.110.0/24
Ether 2:
120:  192.168.120.0/24
Ether 3-5:
130:  192.168.130.0/24
1) Create Bridges

Create bridges for trunk and bridges for each access VLAN

```
/interface bridge
add fast-forward=no name=bridge1trunk
add fast-forward=no name=bridge2vlan110
add fast-forward=no name=bridge2vlan120
add fast-forward=no name=bridge2vlan130
```
2) Create VLAN @BridgeTrk

Add Interfaces VLAN on the Trunk Bridge and put ethernet/wlan (tagged) port into Trunk Bridge Port
Give Name and unique VLAN ID (ex: 110, not 0, 1 or 4095)

```
/interface vlan
add interface=bridge1trunk name=vlan110 vlan-id=110
add interface=bridge1trunk name=vlan120 vlan-id=120
add interface=bridge1trunk name=vlan130 vlan-id=130
/interface bridge port
add bridge=bridge1trunk interface=wlan1
```
3) Untagged VLAN @BridgeAcc

Add **untagged** vlan interface and ethernet (untagged) ports into Access Bridges Port.

```
/interface bridge port

add bridge=bridge2vlan110 interface=vlan110
add bridge=bridge2vlan120 interface=ether2
add bridge=bridge2vlan120 interface=vlan120
add bridge=bridge2vlan130 interface=ether3
add bridge=bridge2vlan130 interface=vlan130
add bridge=bridge2vlan130 interface=ether4
add bridge=bridge2vlan130 interface=ether5
```
VLAN in MikroTik
Wireless Trunk

- Wireless Bridge (AP-Bridge, Station-Bridge) -> bridge to ethernet, etc
- Wireless Distribution System -> Roaming
- Wireless Repeater -> Extend Range
- Tunnel (EoIP, PPTP with BCP) -> Secured Tunneling
**Wireless Bridge**

**R1**
Act as usual **AP Bridge** with specific Band Frequency, SSID and Security Profile
Bridge between wlan and ethernet

**R2**
Act as **Station bridge** for selected Access Point (AP)
Bridge between wlan and ethernet
Bridge VLAN on Wireless Bridge

It is done by creating Vlan Interface (Vlan110, Vlan 120, Vlan 130) on Wireless-Bridge (ie: bridge2wlan-ether)

```
/interface vlan
add interface=bridge2wlan-ether name=vlan110 vlan-id=110
add interface=bridge2wlan-ether name=vlan120 vlan-id=120
add interface=bridge2wlan-ether name=vlan130 vlan-id=130

/interface bridge port
add bridge=bridge2wlan-ether interface=wlan1
```
WDS (Master - Slave)

- WDS Master: as AP-Bridge with specific SSID, Band, Freq and Security Profile
- WDS Slave: same as ap-bridge, but scan for AP with the same ssid and establishes WDS link.
- WDS Master and Slave **MUST BE** Bridge into WDS Default Bridge
Create WDS Bridge

- Create WDS Default bridge with specific name, like: bridge2wds for both Master WDS and Slave WDS
Create WDS Master

- Enable Wlan as AP-Bridge with specific Security Profile
- In tab WDS, set WDS mode Static
- Set WDS Default Bridge to created bridge before (ie: bridge2wds).
Create WDS Master

- In **Wireless Menu** at Wifi Interface Add (+) WDS Interface on Wlan as Master Interface
- Fill WDS Address for WDS **Slave MAC Address**
Create WDS Slave

- Enable Wlan as WDS-Slave
- Tab WDS, set WDS mode Static
- Set WDS Default Bridge to created bridge before (ie: bridge2wds).
Create WDS Slave

- In **Wireless Menu** at Wifi Interface Add (+) WDS Interface on Wlan as Master Interface
- Fill WDS Address for WDS **Master** MAC Address
## RSA (Running, Slave, Active) WDS

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<tr>
<th>Name</th>
<th>Type</th>
<th>Actual MTU</th>
<th>L2 MTU</th>
<th>Tx</th>
<th>Rx</th>
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<td>0 bps</td>
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<td>Ethernet</td>
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<td>0 bps</td>
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<td>1600</td>
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<td>25.5 kbps</td>
<td></td>
</tr>
</tbody>
</table>

**RSA (Running, Slave, Active)**
Bridge VLAN on WDS

- It is done by creating Vlan Interface (Vlan10, Vlan 20, Vlan 30) on WDS Bridge Default (ie: bridge2wds)
**Wireless Repeater**

**R1**
Act as usual  **AP Bridge** with specific Band Frequency, SSID

**R2**
Set wlan1 as  **Station bridge** for selected Access Point (AP)
Create  **Virtual AP (wlan2)** from master interface wlan1
**Bridge between wlan1 and wlan2** as Trunk .OR.
**Bridge wlan2 to Access Bridge** as Access Port
Bridge VLAN on Wireless Repeater

It is done by creating Vlan Interface (Vlan110, Vlan 120, Vlan 130) on Wireless Repeater-Bridge (ie: bridge1wireless)

(interface vlan
  add interface=.bridge1wireless name=vlan110 vlan-id=110
  add interface=bridge1wireless name=vlan120 vlan-id=120
  add interface=bridge1wireless name=vlan130 vlan-id=130)

(interface bridge port
  add bridge=bridge1wireless interface=wlan1
  add bridge=bridge1wireless interface=wlan2)
/interface bridge
add fast-forward=no name=bridge3eoip

/interface eoip
add mac-address=02:A7:59:B2:DB:CB name=eoip-tunnel1
remote-address=192.168.80.1 tunnel-id=111

/interface vlan
add interface=bridge3eoip name=vlan300 vlan-id=300

/interface bridge port
add bridge=bridge2vlan300 interface=eoip-tunnel1
add bridge=bridge2vlan300 interface=ether3
Bridge VLAN on Wireless Tunnel

It is done by creating Vlan Interface (ie: Vlan 300) on Wireless Tunnel-Bridge (ie: bridge3eoip)

```
/interface vlan
add interface=bridge3eoip name=vlan300 vlan-id=300

/interface bridge port
add bridge=bridge2vlan300 interface=eoip-tunnel1
add bridge=bridge2vlan300 interface=ether3
```
Implementation @ EE Ubaya

- There are 3 building TA, TB, TC and Outdoor
- Between building connected wired and wirelessly.
- There is a or several Main Router Board (RB) or Switch in each building
- From the Main RB is connected to Ethernet to some extended RB or switches and several APs
Wireless Scope Area
The Implemented Topology
Hardware Type

- CRS 226-24G-2S-IN
- CRS 125-24G-1S-2HnD-IN
- RB 2011UiAS-2HnD-IN
- RB 952 Ui-5ac2nD
- .......

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VLAN ID Planning

- **VLAN 10**: used for faculty management staff and or laboratory administrator.
- **VLAN 20**: used for lecturers in TA, TB and TC buildings
- **VLAN 30**: used for student in laboratory or class in TA, TB and TC building
- **VLAN 80, 81**: used for roaming student and or outdoor gazebo area
VLAN BRIDGES Planning

- **For TRUNK**
  - Bridge-Trunk : Ether1-2
  - Bridge-TrunkWL : Wlan1,2

- **For ACCESS**
  - BridgeVlan10: Ether 3-8 : VLAN 10
  - BridgeVlan20: Ether 9-16 : VLAN 20
  - BridgeVlan30: Ether 17-24 : VLAN 30
  - BridgeVlan8x: Wlan1,2 : VLAN 80, 81
VLAN ACCESS Port Planning

BridgeVlan10
VLAN ID: 10
VLAN ACCESS Port Planning

BridgeVlan20
VLAN ID: 20
VLAN ACCESS Port Planning

BridgeVlan30
VLAN ID: 30
VLAN ACCESS Port Planning

BridgeVlan8x
VLAN ID: 80, 81
VLAN ACCESS Port Planning

WIRELESS ACCESS (VLAN 80 or VLAN 81)

ROUTERs TA

WIRED ACCESS

VLAN10 20 30

ROUTERs TB

WIRED ACCESS

VLAN10 20 30

ROUTERs TC

WIRED ACCESS

VLAN10 20 30
VLAN TRUNK Planning

WIRELESS TRUNK (VLAN 80, VLAN 81)

ROUTERs TA               ROUTERs TB               ROUTERs TC

WIRED TRUNK

WIRELESS TRUNK

VLAN 10, 20 30

WIRED TRUNK
VLAN Overall Planning

ROUTER GAZ

ROUTER TA2

ROUTER TB2

ROUTER TB3

ROUTER TC2

ROUTER TC3

WIRELESS TR

WIRED TRUNK

10 20 30 80 81

10 20 30
VLAN 10, 20, 30 Plan

- Use for indoor or internal building users (student, laboratory, lecturer, administration staff)
- Use: **Wired trunk** (SFP and Ethernet trunk)
- Router TB2 as **Main Router**: Wan (ether1-2) Trunk (ether3-8)
- Router TAs, TBs, TCs, Outdoors as **Access Router**: Trunk (ether1-2), Access Vlan (10: ether 3-8, 20: ether 9-16, 30: ether 17-24)
Router TB2 (Main Router)

- **WAN**
- **TRUNK VLAN80 81**
- **ACCESS VLAN20 30**
- **TRUNK 10,20,30, 80,81**
Router TAs, TBs, TCs (Access)

TRUNK 10, 20, 30

ACCESS VLAN 10  20  30
VLAN 80, 81 Plan

- **Only use for Roaming** Student between building TA, TB and TC (vlan 80 and 81)
- **Use:** Wireless Trunk - Repeater, AP Bridge, WDS (Master - Slave)
- Router TB: as WDS Master (AP-Bridge)
- Router Outdoor Gazebo: as WDS Slave
- Router Indoor Wireless: AP-Bridge, Station-Bridge, Repeater
VLAN Planning (Vlan 80, 81)

WDS and/or Repeater

ROUTER GAZ1
WDS SLAVE

ROUTER GAZ2
REPEATER

ROUTER GAZ3
WDS SLAVE

AP BRIDGE

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Main Router (TB2) Configuration

WAN
TRUNK 10,20,30, 80,81

ACCESS VLAN20    30

TRUNK VLAN80     81
Main Router (TB2) Configuration

1) To be able to forward tagged packet, we need to create trunk bridge and access bridge.

```
/interface bridge
add fast-forward=no name=bridge-trunk
add fast-forward=no name=bridge-trunkwl
add fast-forward=no name=bridgevlan10
add fast-forward=no name=bridgevlan20
add fast-forward=no name=bridgevlan30
add fast-forward=no name=bridgevlan80
add fast-forward=no name=bridgevlan81
```
Main Router (TB2) Configuration

2a) Create VLAN interface in the trunk bridge

```
/interface vlan
add interface=bridge-trunk name=vlan10 vlan-id=10
add interface=bridge-trunk name=vlan20 vlan-id=20
add interface=bridge-trunk name=vlan30 vlan-id=30
add interface=bridge-trunk name=vlan80 vlan-id=80
add interface=bridge-trunk name=vlan81 vlan-id=81
add interface=bridge-trunkwl name=vlan80w vlan-id=80
add interface=bridge-trunkwl name=vlan81w vlan-id=81
```
2b) Add ethernet (ether3-8) port that we want to forward the VLAN in the trunk bridge

```
/interface bridge port
add bridge=bridge-trunk interface=ether3
add bridge=bridge-trunk interface=ether4
add bridge=bridge-trunk interface=ether5
add bridge=bridge-trunk interface=ether6
add bridge=bridge-trunk interface=ether7
add bridge=bridge-trunk interface=ether8
```
3a) Add ethernet (9-16) interfaces to the Vlan 20 access bridges and ethernet port (17-24) for Vlan 30.

/interface bridge port
add bridge=bridgevlan20 interface=vlan20
add bridge=bridgevlan20 interface=ether9
add bridge=bridgevlan20 interface=ether10
....... 
add bridge=bridgevlan20 interface=ether16
3b) Add ethernet (9-16) interfaces to the Vlan 20 access bridges and ethernet port (17-24) for Vlan 30.

```
/interface bridge port
add bridge=bridgevlan30 interface=vlan30
add bridge=bridgevlan30 interface=ether17
add bridge=bridgevlan30 interface=ether18
....... 
add bridge=bridgevlan30 interface=ether24
```
DHCP Configuration

- Give **IP for each bridgevlan** access then
- Create DHCP Server setup for interface bridgevlan10, 20, 30 and 80, 81 with specific IP Pool addresses.

```bash
/ip dhcp-server
add address-pool=dhcp_pool1 disabled=no interface=bridgevlan10 name=dhcp1
add address-pool=dhcp_pool2 disabled=no interface=bridgevlan20 name=dhcp2
........
add address-pool=dhcp_pool5 disabled=no interface=bridgevlan81 name=dhcp5
```
Network Configuration

- Make a masquerade NAT action output to WAN bridge interface.
  
  `/ip firewall nat
  add action=masquerade chain=srcnat out-interface=bridge1wan`

- Make necessary Firewall need.
- Make a default gateway route and IP Route for internal VLAN route if necessary.
Centralized Network Management

- Centralized DHCP Server
- Centralized QoS (Simple Que, HTB)
- Centralized Route Management (Policy Routing, Route-Rules)
- Centralized Firewall (NAT, Filter, Mangle)
- Centralized Wireless Management (CapsMan)
Access Router Configuration (TAs, TCs, TBs)

Trunk: ether1, Access: ether 2-8 (10), 9-16(20), 17-24(30)

```
interface vlan
add interface=bridge-trunk name=vlan10 vlan-id=10
add interface=bridge-trunk name=vlan20 vlan-id=20
add interface=bridge-trunk name=vlan30 vlan-id=30
add interface=bridge-trunk name=vlan20 vlan-id=80
add interface=bridge-trunk name=vlan30 vlan-id=81
interface bridge port
add bridge=bridge-trunk interface=ether1
```

TRUNK port (ex: ether1)
Access Router Configuration (TAs, TCs, TBs)

Trunk: ether1, Access: ether 2-8 (10), 9-16(20), 17-24(30)

/_interface bridge port
add bridge=bridgevlan10 interface=vlan10
add bridge=bridgevlan10 interface=ether2
........
add bridge=bridgevlan10 interface=ether8
........
add bridge=bridgevlan30 interface=vlan30
add bridge=bridgevlan30 interface=ether17
........
add bridge=bridgevlan30 interface=ether24
Access Router Configuration (GAZs, Outdoors)

Trunk: wlan1, WDS: Master-Slave
Create Vlan80, 81 on WDS Bridge

```
/interface bridge
  add fast-forward=no name=bridge2wds
/interface bridge port
  add bridge=bridge2wds interface=wlan1
/interface vlan
  add interface=bridge2wds name=vlan80 vlan-id=80
  add interface=bridge2wds name=vlan81 vlan-id=81
/interface wireless wds
  add disabled=no master-interface=wlan1 name=wds1 wds-address=D4:CA:6D:0C:26:CA
  add disabled=no master-interface=wlan1 name=wds2 wds-address=4C:5E:0C:32:76:4F
```

........

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Conclusion & Discussion

- Bridging vlan (wired and wireless) makes network management easier and centralized.
- VLAN could be put or attached in bridge or physical interface.
- When you add an interface to a bridge, the bridge becomes the master interface and all bridge ports become slave ports, this means that all traffic that is received on a bridge port is captured by the bridge interface and all traffic is forwarded to the CPU using the bridge interface instead of the physical interface.
Conclusion & Discussion

- With bridges, it is easy to show and manage the trunk port or access port.
- Always disable VLAN filtering first, before you are sure about your VLAN setting!
- Always give the specific IP to the bridges for ease of maintenance and trouble-shooting.
- Bridging in wireless, we should use station-bridge or bridge mode, don't use station only mode.
- The disadvantage of wds and repeater link is the reduction of the throughput on the wireless side.
References

Credit to

- MikroTik and MUM Yogyakarta 2018 Committee
- Telecommunication and Network Design Laboratory (TND - Ubaya)
- Mr. Herry Darmawan and Team
- Elektro UBAYA Training Center (EUTC)
- My Colleagues
Thank you