

Preparation of IT infrastructure for Digital Classroom

Quick Guide



Seeing beyond

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1. Basic Knowledge of Network Terms

1.1 Byte and bit are units of digital information which are used in network.

1 Byte = 8 bits

1 KB = 1024 Bytes

1 MB = 1024 KB

bps means “bits per second”. It is a very important indicator that describe the bandwidth capacity and data rate.

It indicates the transferring speed of network infrastructure.

Bps means “Bytes per second”. 1 Bps = 8 bps.

1.2 MAC address and IP address

MAC address (media access control address) is a unique identifier assigned to a network interface controller (NIC) for communications at the data link layer of a network segment.

You can consider it as the ID of every device in the network.

It tells everyone in the network “**who am I**”.

IP address (Internet Protocol address) is a numerical label assigned to each device connected to a computer network that uses the Internet Protocol for communication. An IP address serves two principal functions: host or network interface identification and location addressing.

You can consider it as the address of every device in the network. It tells other devices in the network “**where am I**”.

1.3 DHCP

DHCP (Dynamic Host Configuration Protocol) is a network management protocol used on UDP / IP networks whereby a DHCP server dynamically assigns an IP address and other network configuration parameters to each device on a network so they can communicate with other IP networks.

You can consider it as a **tool** that automatically **assign** IP addresses to all devices in the network.

1.4 Router, Switch and AP

Router is a networking device that forwards data packets between computer networks. For regular household wireless router, it has the function of both wireless connection and routing. And DHCP is always a default functionality, then it could assign IP address automatically to every devices connected to this router.

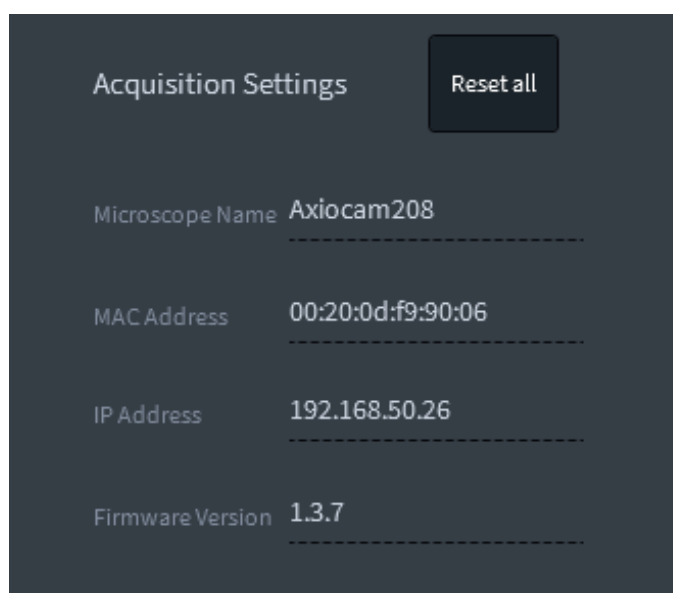
Switch (also called switching hub, bridging hub, officially MAC bridge) is a computer networking device that connects devices together on a computer network by using packet switching to receive, process, and forward data to the destination device. It has two types: layer 3 switch, and layer 2 switch. The layer 3 switch (also called multilayer switch) has routing and DHCP function. And it can be treated as a more powerful router but without wireless function. The layer 2 switch doesn't have routing and DHCP function. It only transfers data based on MAC address.

Access point (AP), is a networking hardware device that allows a Wi-Fi device to connect to a wired network. The AP usually connects to a router (via a wired network) as a standalone device. In functionality wise, we can see a **Wi-Fi Router** is close to the combination of **layer 3 switch + AP**.

1.5 Wi-Fi 2.4 GHz and 5 GHz

2.4 GHz and 5 GHz are both frequency range of Wi-Fi. Wi-Fi most commonly uses the 2.4 GHz (12 cm) UHF and 5.8 GHz (5 cm) SHF ISM radio bands, these bands are subdivided into multiple channels. The bandwidth of 5G signal is much more than 2.4 GHz.

In digital classroom, we recommend to use 5 GHz for the connection.



The MAC address and IP address can be found through the router's configuration page or the Acquisition Settings (Advanced) in Labscope.

1.6 UDP broadcast

UDP (User Datagram Protocol) is a communications protocol that is primarily used for establishing low-latency and loss-tolerating connections between applications on the internet.

Broadcasting: In computer networking, broadcasting refers to transmitting a packet that will be received by every device on the network.

Labscope uses UDP broadcast for automatically discover the microscopes/cameras in the network.

1.7 VLAN and Subnet

VLANs (Virtual LANs) are logical grouping of devices in the same broadcast domain. VLANs are usually configured on switches by placing some interfaces into one broadcast domain and some interfaces into another.

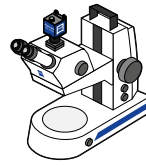
Subnets or subnetworks are logical subdivisions of an IP network. The practice of dividing a network into two or more networks is called subnetting.

VLANs and Subnets have similarities that both methods restrict broadcast domains or ensure security through isolation of different VLANs or Subnets.

For digital classrooms, the Labscope's automatic discovering for microscopes/cameras by UDP broadcast **cannot work** when the Labscope device (Phone, tablet, Laptop or PC) is in **different** VLANs or Subnets with microscopes. If they are in different VLANs or Subnets, you need to manually add IP address for establishing the connection, please see chapter [4. recommended IT conditions for digital classroom; P.6]

2. An overview of possible needed devices for digital classroom

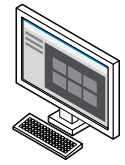
Classroom devices



*Microscopes with cameras



*Laptops / Tablets / PCs / Smartphones

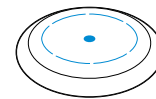


Screens / Projector

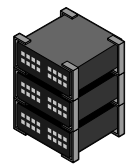
Network devices



Wi-Fi Routers



Access points



Switches

Accessories

- Network cables
- Electrical outlets
- Central controller of classroom devices
- Chargers of tablets, etc.

Other supportive tools (depending on the needs)

- Apple TV for projecting iPad screen to a monitor.
- Tablet holder, can be also used for drawing function.
- Tablet cabinet for tablet charging and storage.



Digital Classroom at the Queensland University of Technology, Brisbane Australia

Info:

The necessity of each device depends on the real digital classroom case and users' requirements. And please see [8. Examples of digital classroom without Labscope Teacher, P. 10] and [9. Example of digital classroom with Labscope Teacher, P. 17] for some typical examples.

***Note:** in the guide, the term "Microscope" represents for the microscope with camera. The term "Tablet" is used for representing all the terminal devices including laptops, PCs, tablets and smart phones. For detailed supported operating system and functional differences on different OS platforms, please refer to Product Info Labscope.

3. An overview of different wireless connection ways



AP mode:

Connect to Wi-Fi adapter of ZEISS microscope directly.

Application scenario:

Connections for **one microscope to one or two tablets**.

E.g. for Primostar 3, such connection supports up to two tablets for seeing one live view image simultaneously.



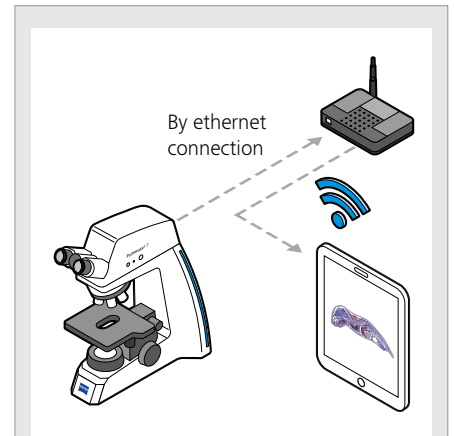
STA mode:

Use a Wi-Fi router as a bridge to wirelessly connect the microscope and tablets.

Application scenario:

Connections for **one microscope to several tablets**.

E.g. for Primostar 3, such connection supports around 8 tablets for seeing the live view image simultaneously.



Ethernet to Wi-Fi connection:

Connect to the Primostar 3 with a Wi-Fi router by ethernet cable. Then wirelessly connect tablets to the router.

Application scenario:

Connections for **one microscope to many tablets**.

E.g. for Primostar 3, such connection supports dozens of tablets for seeing the live view image simultaneously.

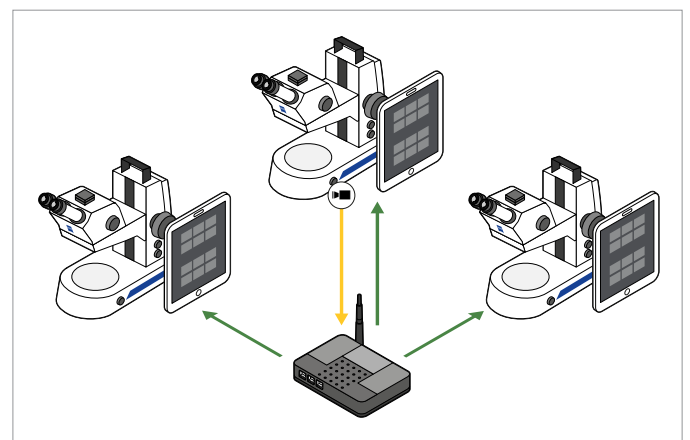
Here we use Primostar 3 HD as an example, to show the 3 kinds of wireless connection ways between microscope and tablet. Please note different microscopes/cameras have different possibilities of connection ways, e.g. some support direct Ethernet and USB connections, some does not support Wi-Fi adapter connections. Please read the manual of relevant microscope/camera for details.

The below image illustrates the case of students are seeing one live image from just one microscope simultaneously.

From the illustration, the live image stream is sent out from one microscope, then passed through a router and reached to every tablets. This is a case when a student is doing a demonstration, and other students from the group are watching the live view image at the same time. In such case, for a pure wireless connection, the Wi-Fi adapter's performance becomes a bottle neck for the network bandwidth. That's also the reason that the Ethernet to Wi-Fi connection can provide higher capacity for seeing live view simultaneously. Besides, Ethernet to Wi-Fi connection also provides better network stability.

Therefore, for digital classrooms, the recommended way is to use the Ethernet to Wi-Fi connection for higher capability and better connection stability.

You can also restrict the students for only being able to see their own microscopes. For achieving this, you could use the function of "Only use this microscope" in microscope configuration of Labscope. This function also reduces certain network traffic.



Note: The number of connected tablets **for seeing one live image simultaneously** mentioned above is not a restrictive number, but rather a recommended number. And it also depends on the Wi-Fi router's performance, live quality settings in Labscope, camera types and network environments, etc. These numbers are not related to "How many microscopes and tablets can be connected in a digital classroom".

Only use this microscope

Or you can use Labscope Teacher to configure the classroom with clear assignment about who to see which microscope. Moreover, Labscope Teacher provides more interactive teaching and learning functions. For details, please refer to the guide of Labscope Teacher.

4. Recommended IT conditions

4.1 For digital classroom case without Labscope Teacher server:

1. UDP broadcast of the network is enabled.

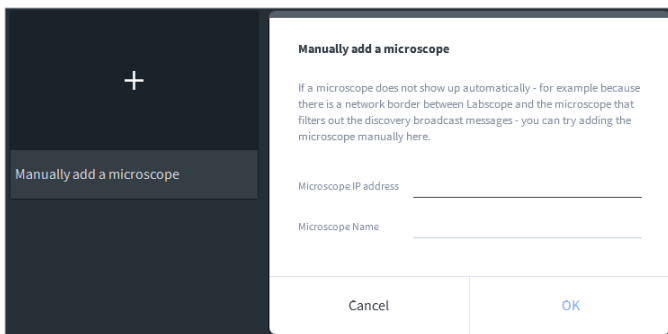
Labscope uses UDP broadcast to automatically discover the microscopes in the network.

If it must be disabled from school's IT regulation, the microscopes would not be automatically discovered by Labscope. But users can still use the function of "Manually Add a Microscope" in Labscope to establish the connection. Below shows the steps to achieve this. In Labscope, firstly activate the function in global settings.

Microscopes can be added manually



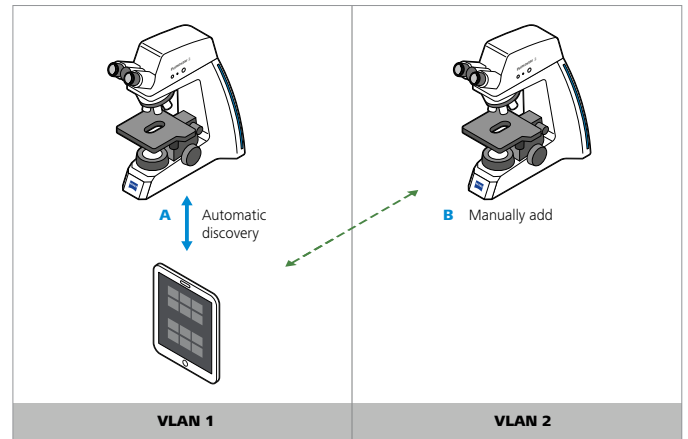
Then an empty slot named as "Manually add a microscope" appears in microscope view, and just click and input the correct IP address of the Microscope. Please see [1.2 MAC address and IP address, P. 3] for how to get the IP address of microscope.



2. Microscopes and tablets are in one VLAN and one Subnet

UDP broadcast does not work from tablet to microscope when they are in different VLANs or subnets, and it leads to failure for the automatic discovery. That is the reason we recommend to put devices in one VLAN and one subnet.

If the devices need to be allocated into different VLANs or subnets, the function of "Manually Add a Microscope" is still the solution. The below picture illustrates the situation of manually adding B microscope on the tablet to establish the connection once they are in different VLANs. And different subnets have similar situation.



This is the illustration of when microscopes are in different VLAN with Tablets.

4.2 For digital classroom case with Labscope Teacher server:

1. UDP broadcast of the network must be enabled.

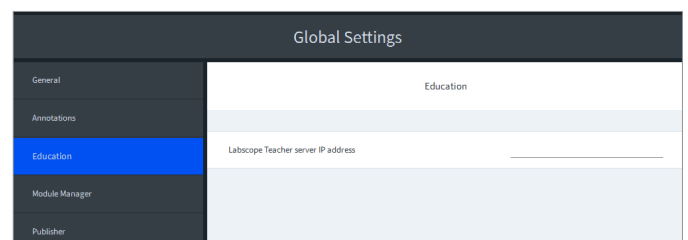
Labscope Teacher requires UDP broadcast to create the microscope list and maintain the microscopes' online/offline status. Therefore, the Labscope Teacher cannot work once the UDP broadcast is disabled.

2. Labscope Teacher server and all microscopes must be in one VLAN and one Subnet.

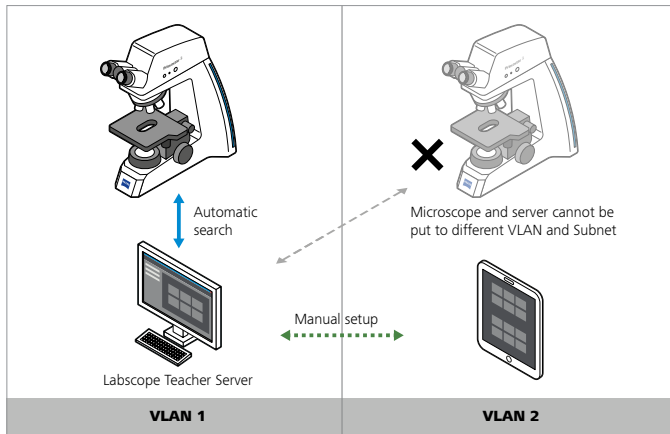
This is also because the UDP broadcast does not work across different VLANs or Subnets.

For Labscope Teacher case, only the tablets can be put to other VLANs or Subnets if necessary, and you just need to input the IP address of the Labscope Teacher server to manually establish the connection. It is like the "Manually add a microscope" function, the difference is here just need to add the server IP instead of microscope's IP. Below describes the steps to achieve this.

After the education module is activated in Labscope via Module Manager, just input the correct IP address of Labscope Teacher server in the Education tag of Global Settings. Please note, you don't need to input server IP if the tablets are in one VLAN and one Subnet with the server.



The below picture illustrates the situation of manually setting server IP to establish the connection of tablet and server when they are in different VLANs. Please note again, the microscopes and server must be in one same VLAN. And different subnets have similar situation.



This is the illustration of when tablets are in different VLAN with Labscope Teacher server.

5. Required network protocols

Network protocols used by Labscope

- Labscope discovers the microscopes via broadcasting discovery packets. If the UDP broadcast is disabled for Labscope device, Labscope can connect microscope via manually inputting IP address. Please see [4.1 Recommended IT conditions for digital classroom case without Labscope Teacher server, P. 6].
- For different cameras and microscopes, the protocols used for live streaming, snap, camera and microscope control, etc. are different. The summarized protocols are for Labscope supported microscopes/cameras in general:
 - TCP (Ports: 80, 5000, 8080, 8090, 8554, 8557)
 - UDP (Ports: 3956, 8557, 8554, 8990, 8995)

Network protocols used by Labscope Teacher

- Labscope Teacher requires UDP broadcast to create the microscope list and maintain the microscopes' online/offline status. Therefore, the Labscope Teacher cannot work once the UDP is disabled. Please see [4.2 Recommended IT conditions for digital classroom case with Labscope Teacher server, P. 6].
- Labscope Teacher uses the following ports to communicate with the service. Keeping all ports available is prerequisite as well. The ports are: 5005, 5100, 5000, 9998.
- Labscope communicates with the Labscope Teacher server via a proprietary HTTP-based protocol (Port: 5000).
- For other Labscope used protocols, please see the above-mentioned points.

6. Recommended network device types and settings of network and Labscope

Please note below contents are just recommendations for digital classroom cases, please consider and adjust according to the actual situation and requirements.

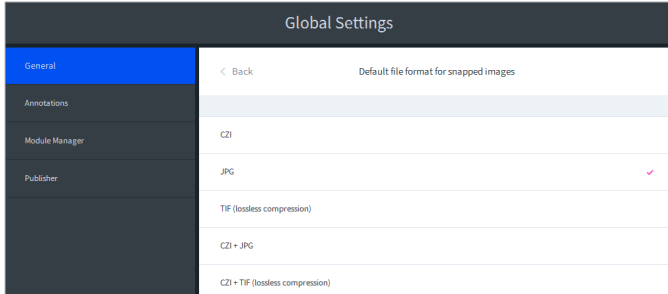
6.1 Recommended network devices and the settings:

- **Connection method:** Ethernet connections from microscopes to routers; wireless connections from tablets to Wi-Fi routers or APs.
- **Network cable type:** CAT-6 (speed up to 1,000 Mbps); CAT-7 (speed up to 10,000 Mbps) or above, based on digital classroom sizes and the required bandwidth for the connection. Please see examples in [8.2 Example of medium digital classroom with 20 microscopes and 20 tablets. P. 11] and P. 13.
- **Network card speed:** 1,000 Mbps capacity or above
- **Ethernet ports:** For switches, RJ45/SFP for Gigabit (1GbE) or 10 Gigabit (10GbE). That depends on the required bandwidth for the connection. And the number of total ethernet ports should satisfy the total number of wired connected microscopes and other devices. For APs, the minimum required ethernet port of AP is 100/1000M. For some cases, you would even need the port of AP with 100/1000/2500M capacity. Please see examples in [8.2 Example of medium digital classroom with 20 microscopes and 20 tablets. P. 11] and P. 13.
- **Wi-Fi protocol:** Wi-Fi-6 (802.11ax) or Wi-Fi-5 (802.11ac)
- **Wi-Fi network band:** 5GHz (please note for some Wi-Fi adapters or ZEISS cameras, only 2.4 GHz is supported, and you could still bridely connect to a dual band 2.4 GHz /5 GHz Wi-Fi router)
- **Types of Wi-Fi routers, APs and Switches:** the major brands from like Cisco, H3C, Huawei, ASUS, TP-Link, Aruba are fine to use. And the data rate of the device should satisfy the network bandwidth requirements for the digital classroom; the bandwidth capacity of the cable port is also a major factor. Please see [7. how to calculate the required bandwidth of digital classroom networks, P. 8] and following examples from P. 10.
- **IP assignment:** Both DHCP and manual IP are fine. Only IPv4 is supported.
- **Wireless settings:** "Guest Network" is not recommended. If it has to be used, please ensure that it can "allow to access internal network". And please set different SSID for different APs/Wi-Fi routers, so that the Labscope devices can be allocated to each WIFI SSID evenly.
- **Required IT conditions and network protocols:** please see [4. Recommended IT conditions, P. 6] and [5. required network protocols, P. 7].
- **Firewall settings:** please set Labscope and Labscope Teacher related programs for having the permission to bypass the firewall. For setting the rules of ports and protocols, please see [4. Recommended IT conditions, P. 6] and [5. required network protocols, P. 7].
- **Anti-virus software settings:** if needed, please add the following programs into the whitelist: Labscope3.exe; LabscopeService.exe; CefSharp.BrowserSubprocess.exe; LabscopeTeacher.exe; ZENStorageServerGateway.exe; ZENIdentityServer.exe; Zeiss.Micro.DigitalManager.Hosting.WebHost.exe.

6.2 Recommended settings in Labscope

For considering to save bandwidth capacity and ensure the performance of the data transmission in the digital classroom, here we list few recommended settings for Labscope.

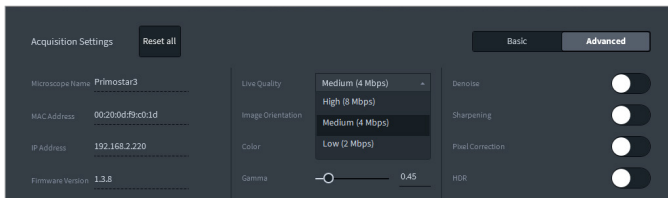
- **Snapped image format:** set to JPG as default in Global Settings.



- **Apply “only use this microscope” for students’ Labscope devices:** If VLAN is not used to divide the students’ devices into groups, the function of “only use this microscope” is recommended for students’ devices. Then each student can just see their own microscope image which saves the bandwidth.



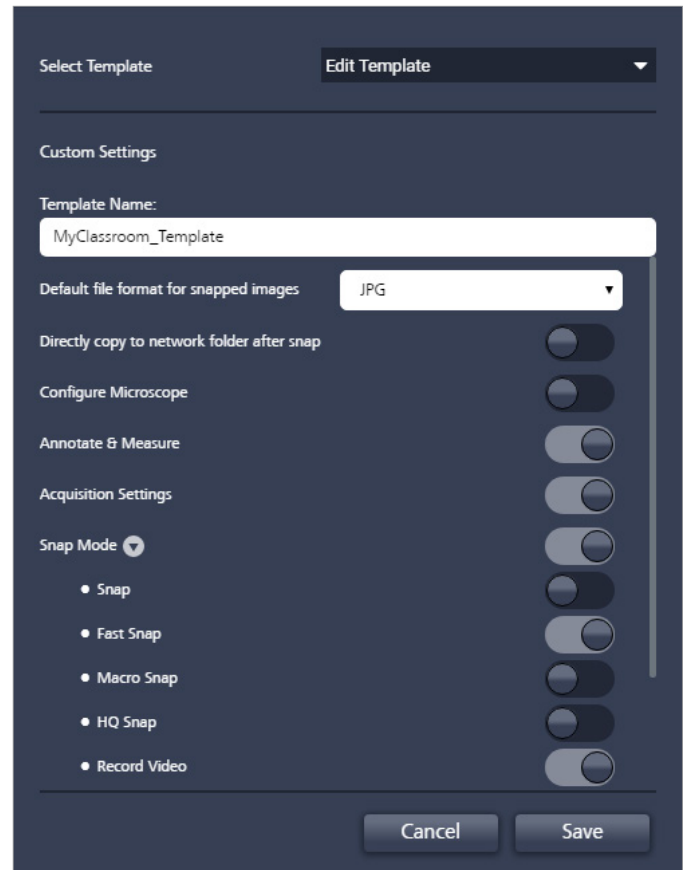
- **Set to Medium for image quality in advanced Acquisition Settings:** this is to be adjusted according to the network performance of the classroom.



- **Use Fast Snap mode to acquire images:**



- **For Classroom with Labscope Teacher, configure the authorization for all students in an ease:** In classroom template “Labscope Settings”, set to JPG format as default, and the snap mode can be limited to only Fast Snap and so on by teacher. The microscopes’ visit authorization for whom can see which microscopes can be set as well by teacher using Labscope Teacher, to better control the usage and bandwidth occupation in the classroom.



7. How to calculate the required bandwidth of digital classroom network

7.1 For the case that the device ratio of tablets to microscopes at around 1:1

This is for case that the number of tablet is same or about the same number of microscopes. In the digital classroom, the data transmit from microscope to network devices then to Labscope, and the snapping acquisition always occupies the highest bandwidth. Therefore, we use the snapping data rate for the calculation, and we also leave 50% buffer capacity for the network devices, then it should multiply by 2.

So, the formula for a rough calculation is:

$$\text{Required Wi-Fi bandwidth} = \text{Snapping data rate} \times \text{number of tablets} \times 2$$

Note: The formula is just for a rough estimation of the required bandwidth. It is applicable for the situation of Ethernet to Wi-Fi connection. It does not apply to the Wi-Fi adapter’s cases. The actual data rate in the digital classroom varies according to many factors, e.g. the different using scenarios, different combination ratio between microscopes and tablets, the network environment with other Wi-Fi’s interference, etc.

snapping data rate in Labscope is also related to many factors, e.g. camera types, snapping resolution, exposure time, etc. Below chart listed the experimental data based on different camera types, and please note the different situations have certain fluctuations.

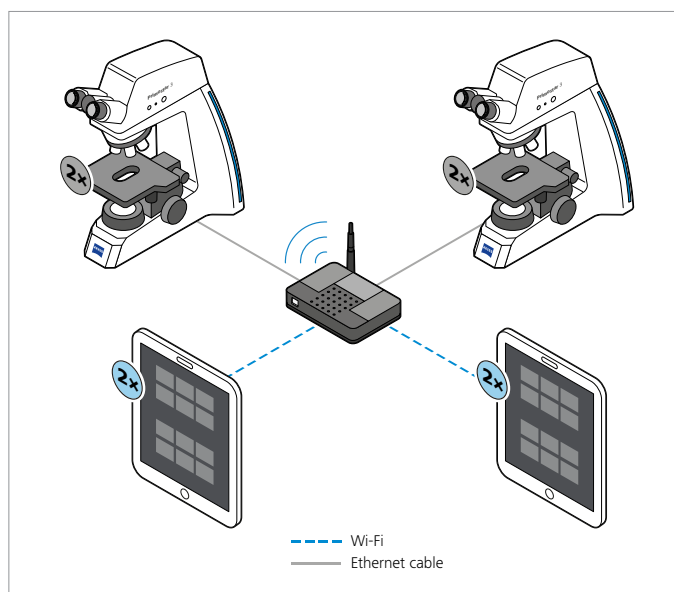
Camera types (or microscopes)	Rough snapping data rate
Axiocam 208, Primostar 3 HD	65 Mbps (snap resolution 3840 × 2160)
ERc 5s, Primo Star HD, Primovert HD, Primotech 5MP	30 Mbps (snap resolution 2560 × 1920) 10 Mbps (snap resolution 1280 × 720)
Primotech 3MP	25 Mbps (snap resolution 2048 × 1536)
Stemi 305 cam	5 Mbps (snap resolution 1280 × 960)

For example, there are 4x Primostar 3 HD microscopes need to connect to 4 tablets, which kind of Wi-Fi routers and how many are needed?

Let's calculate the bandwidth requirement:

$$65 \text{ Mbps (snapping data rate of Primostar 3 HD)} \times 4 \text{ (number of tablets)} \times 2 = 520 \text{ Mbps.}$$

Then we can select one Wi-Fi router with 1,000 Mbps capacity on 5 GHz Wi-Fi connection. And the connection is illustrated in below picture.



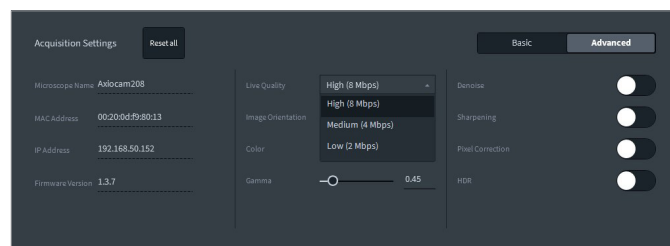
7.2 For the case that the device ratio of tablets to microscopes is more than 1:1

For cases that number of tablets is more than the number of microscopes, e.g. 1 microscopes + 2 tablets, since one microscope only allows one tablet to snap an image at a time, when one tablet is doing a snap, the other connected tablet is not able to snap for the same microscope, instead it just stays on the live view. And the required bandwidth would be (snapping data rate × 1+ live data rate × 1) × 2.

Therefore, the general formula is

$$\text{Required Wi-Fi bandwidth} = ((\text{Snapping data rate} \times \text{number of microscopes} + \text{Live data rate} \times (\text{number of tablets} - \text{number of microscopes})) \times 2$$

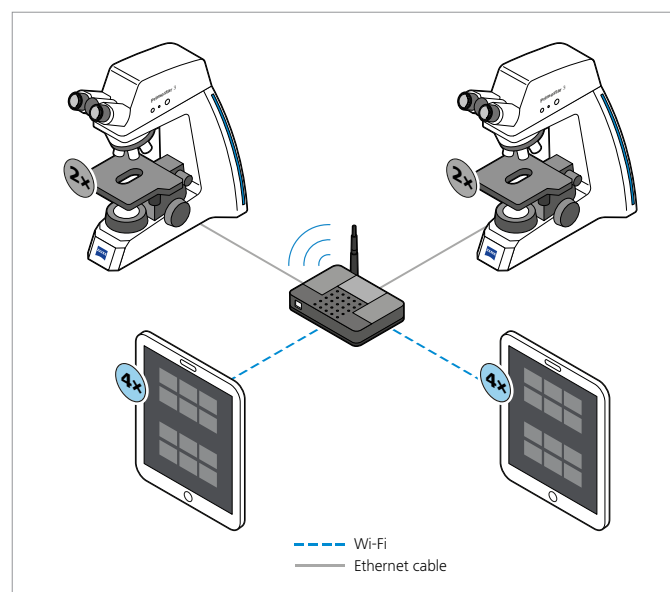
Note: The snapping data rate can refer to the data table on the left side. For live data rate, please refer to the settings in Labscope, in advanced camera settings. For Primostar 3 HD or Axiocam 208 for example, the live quality can be selected from 2, 4, to 8 Mbps.



For example, there are 4x Primostar 3 HD microscopes needed to connect to 8 tablets, and the live stream quality is set to 8 Mbps, which kind of Wi-Fi routers and how many are needed for such case?

Let's calculate the bandwidth requirement: (65 Mbps (snapping data rate of Primostar 3 HD) × 4 (number of microscopes) + 8 Mbps (live data rate) × (8-4) (number of tablets - number of microscopes)) × 2 = 584 Mbps.

Then we can select one Wi-Fi router with 1,000 Mbps capacity on 5 GHz Wi-Fi connection. And the connection is illustrated in below picture.



8. Examples of digital classroom without Labscope Teacher

8.1 Example of small digital classroom with 10 microscopes and 10 tablets

Here the microscope Primostar 3 HD is used for examples. For other camera and microscope types, please just use the relevant snapping data rate for the calculation, please see [7. How to calculate the required bandwidth of digital classroom network, P. 8]

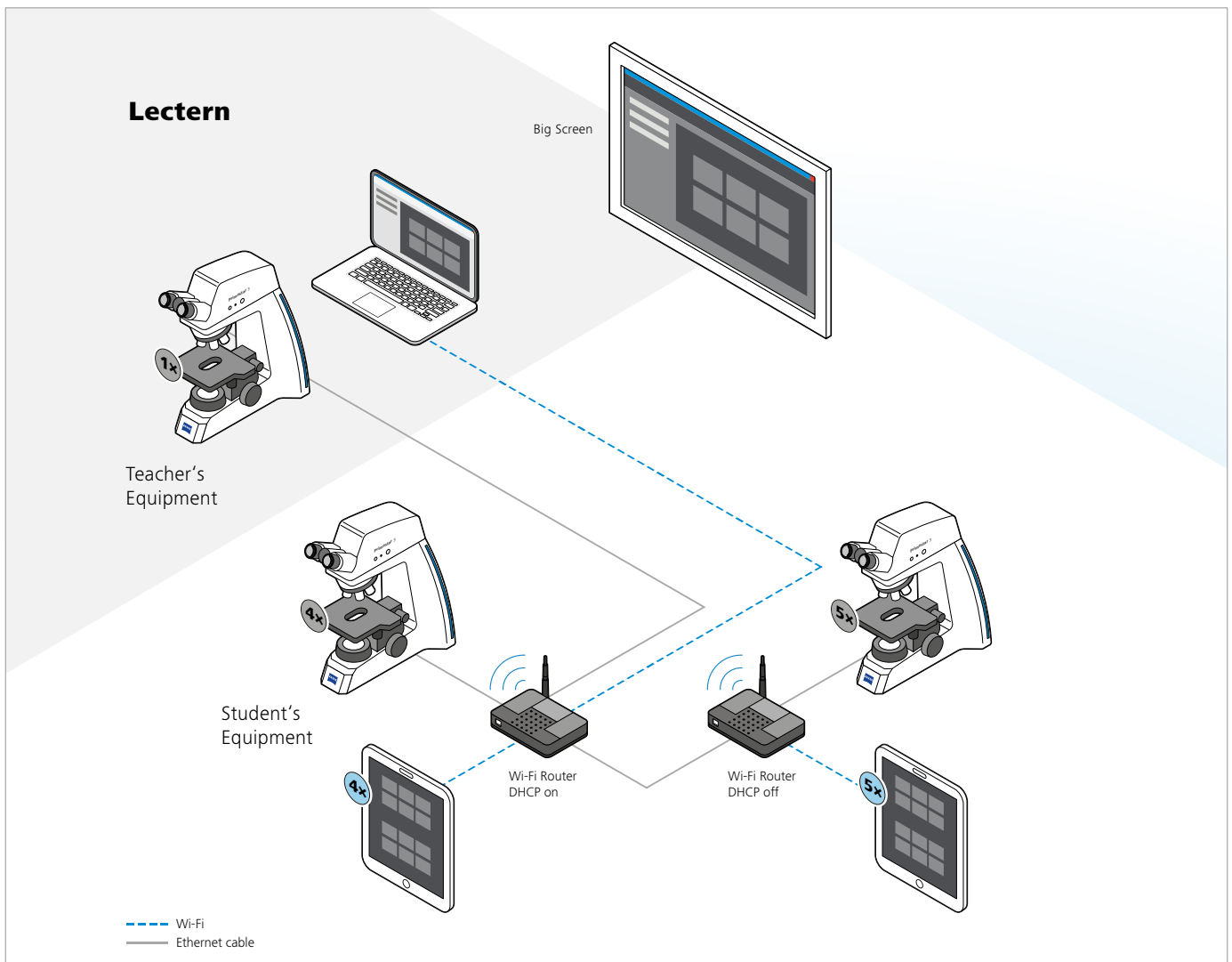
Required Wi-Fi bandwidth / data rate:

65 Mbps (snapping data rate) × 10 (number of tablets) × 2 = 1,300 Mbps

- **Two** Wi-Fi routers with each over 1,000 Mbps Wi-Fi capacity @ 5 GHz would be OK. And bridge connection (LAN-LAN) is used for the two Wi-Fi routers.

- **Each** Wi-Fi router should have at least 6 LAN ports to support Ethernet connection with Microscopes and the other Wi-Fi router. (Each router's five LAN ports are for microscope connection and one for bridge connection with the other Wi-Fi router)
- **One** Wi-Fi router needs to turn on the DHCP for automatically assign IP addresses, and the other one just need to turn off the DHCP.

Note: most types of Wi-Fi routers have specifications of 4, 6 or 8 LAN ports. And most Wi-Fi router's spec will write a sum data rate of 2.4 GHz plus 5 GHz, so please check the detailed spec of its 5 GHz data rate. Please see the connection illustration below.



Note: The illustrated layout is for your reference. Please consider and implement according to the actual situation and requirements of your digital classroom.

8.2 Example of medium digital classroom with 20 microscopes and 20 tablets

Here the microscope Primostar 3 HD is used for examples.

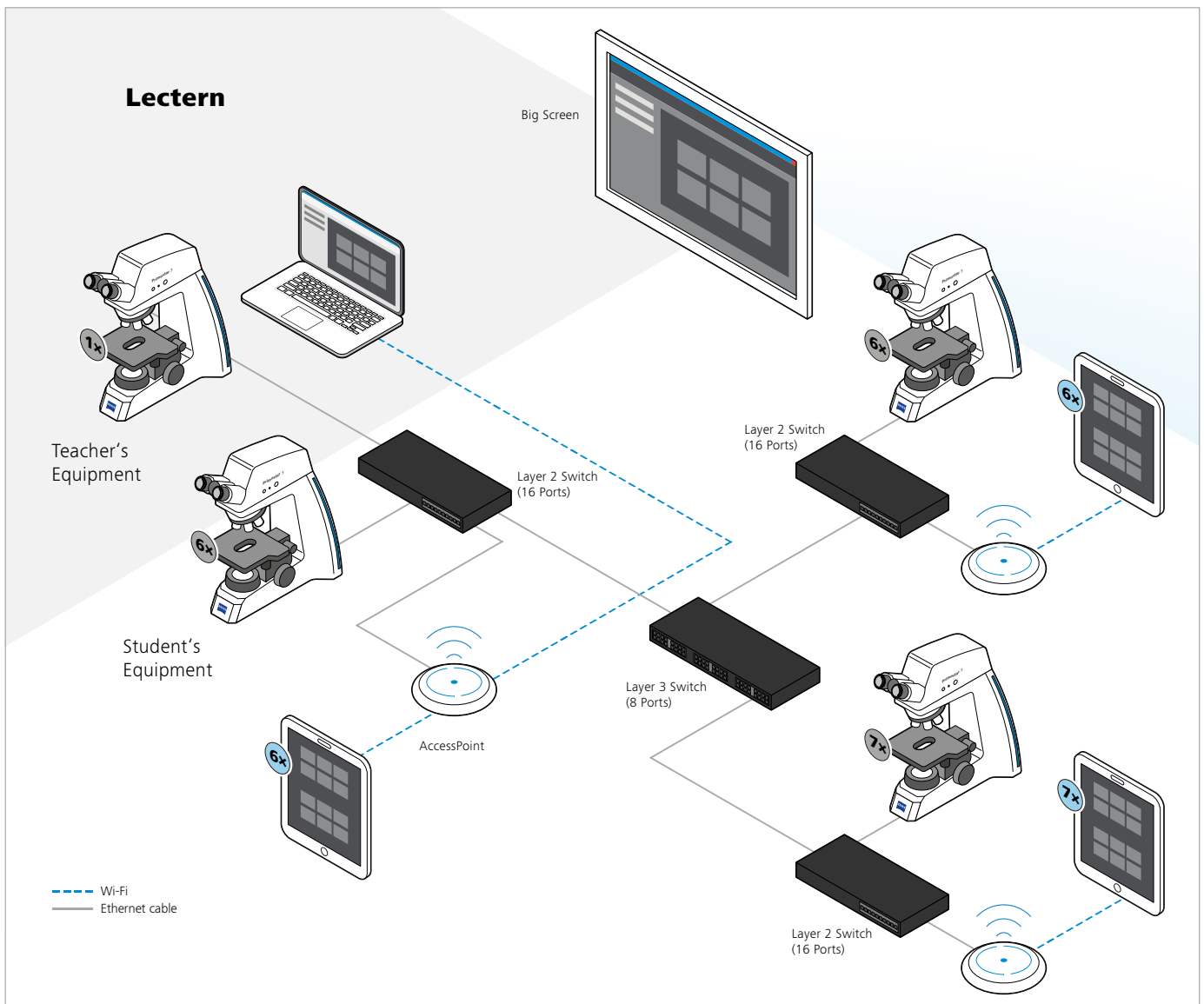
Required Wi-Fi bandwidth / data rate:

65 Mbps (snapping data rate) × 20 (number of tablets) × 2 = 2,600 Mbps

- For medium digital classroom, the **combination of layer 3 switch and APs** are recommended for replacing the Wi-Fi routers. You probably also need additional **layer 2 switches** according to the needed LAN ports and classroom layout for connecting microscopes and APs by ethernet cable.
- **The switches should have at least 23 LAN ports** to support Ethernet connection with Microscopes and APs (20 ports are for microscope connection and 3 for APs). Here the example uses an 8 ports layer 3 switch plus additional three 16 ports layer 2 switches.

- **Three APs with each over 1,000 Mbps Wi-Fi capacity @ 5 GHz** would be OK.
- **Please note! Let's consider which types of cable and Ethernet Ports are necessary for the case.** The maximum required bandwidth of the connections between each switch and AP could be 65 Mbps (snapping data rate) × 7 (number of tablets) × 2 = 910 Mbps; therefore, the 1GbE ports and CAT-6 cables with 1000 Mbps capacity would be still fine for the connections between APs and Switches.

Note: most types of switches have 8, 16, 24 or 48 LAN ports. And different ports' capacity can vary from 1 GbE to 10 GbE and so on. Currently most APs' Ethernet port parameter could be 100M, 100/1000M or 100/1000/2500M, for this case the 100/1000M type is necessary for satisfying the data rate of 1000 Mbps. Please select proper types of switch, AP and ethernet cable according to the actual situation.



Note: The illustrated layout is for your reference. Please consider and implement according to the actual situation and requirements of your digital classroom.

8.3 Example of big digital classroom with 30 microscopes and 30 tablets

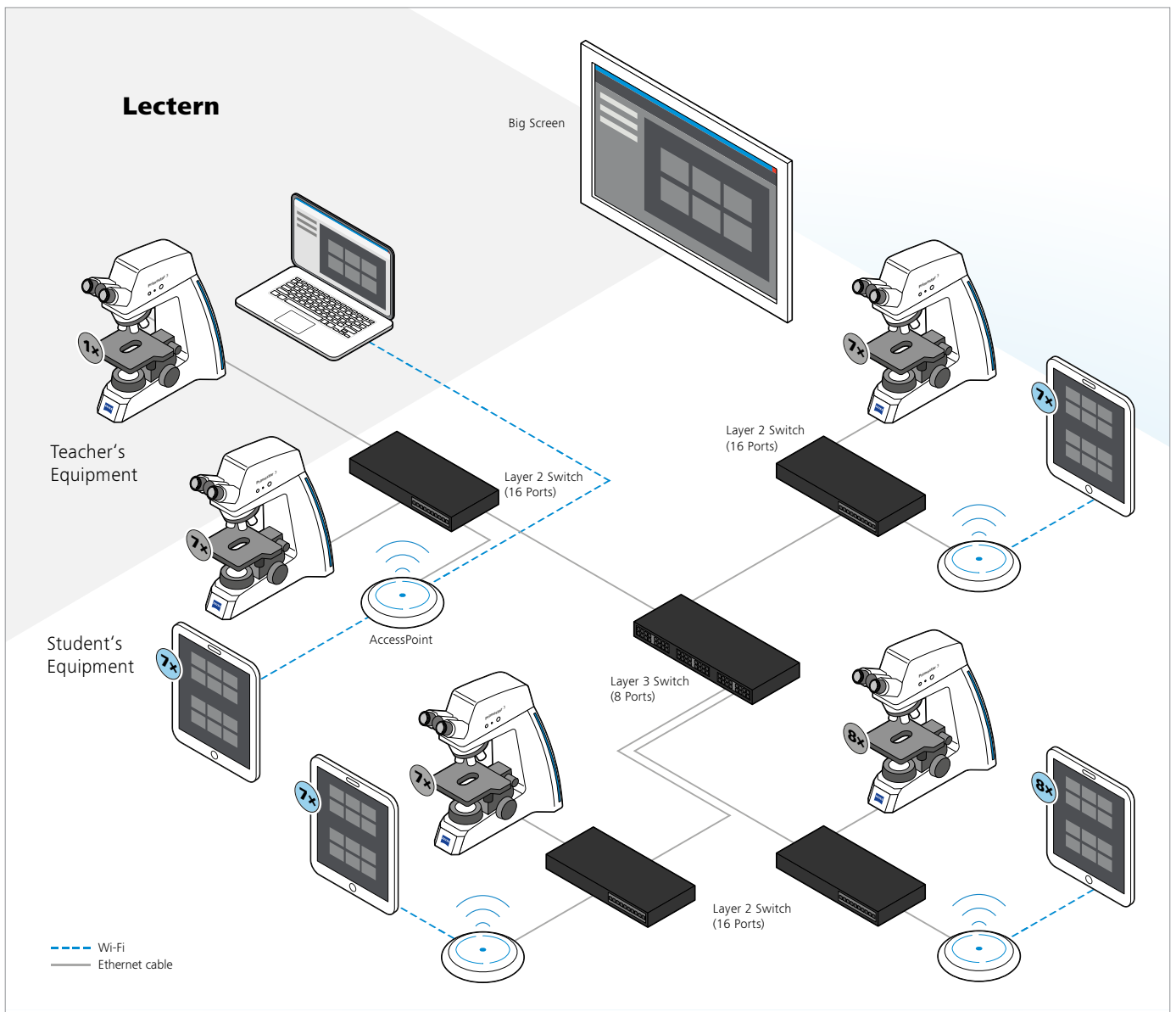
Here the microscope Primostar 3 HD is used for examples.

Required Wi-Fi bandwidth / data rate:

65 Mbps (snapping data rate) × 30 (number of tablets) × 2 = 3,900 Mbps

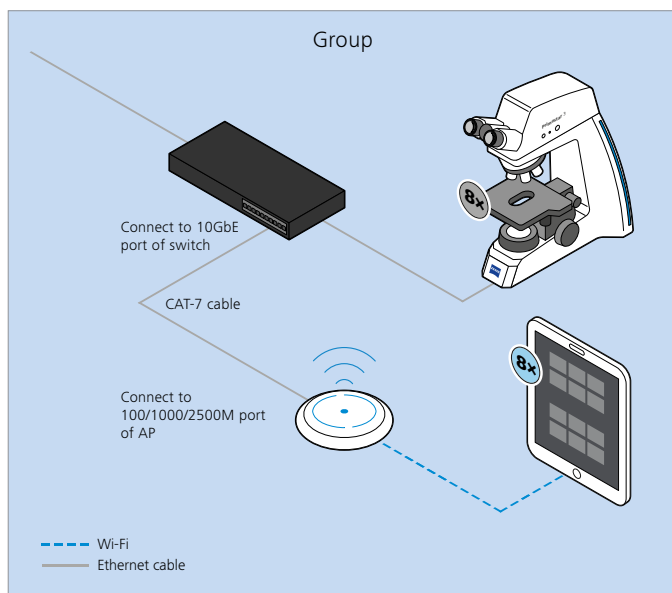
- For big digital classroom, the **combination of layer 3 switch, layer 2 switches and APs** are recommended.
- **Four APs** with **each** over **1,500 Mbps** Wi-Fi capacity @ 5 GHz would be OK.

- Totally you need more than **34 LAN ports** (30 microscopes + 4 APs). Here the example uses an 8 ports layer 3 switch plus additional four 16 ports layer 2 switches.
- **Please note!** For this case, the maximum required bandwidth of the connections between each switch and AP could be 65 Mbps (snapping data rate) × 8 (number of tablets) × 2 = 1040 Mbps which is just over 1,000 Mbps, therefore the CAT-6 cables, 100/1000M ports of AP and 1GbE port of switch may not be enough for proving a stable data transmission. You could consider to use higher capacity devices just for the groups with more than 8 Primostar 3 HD. Please see the detailed explanation in next page P. 13.

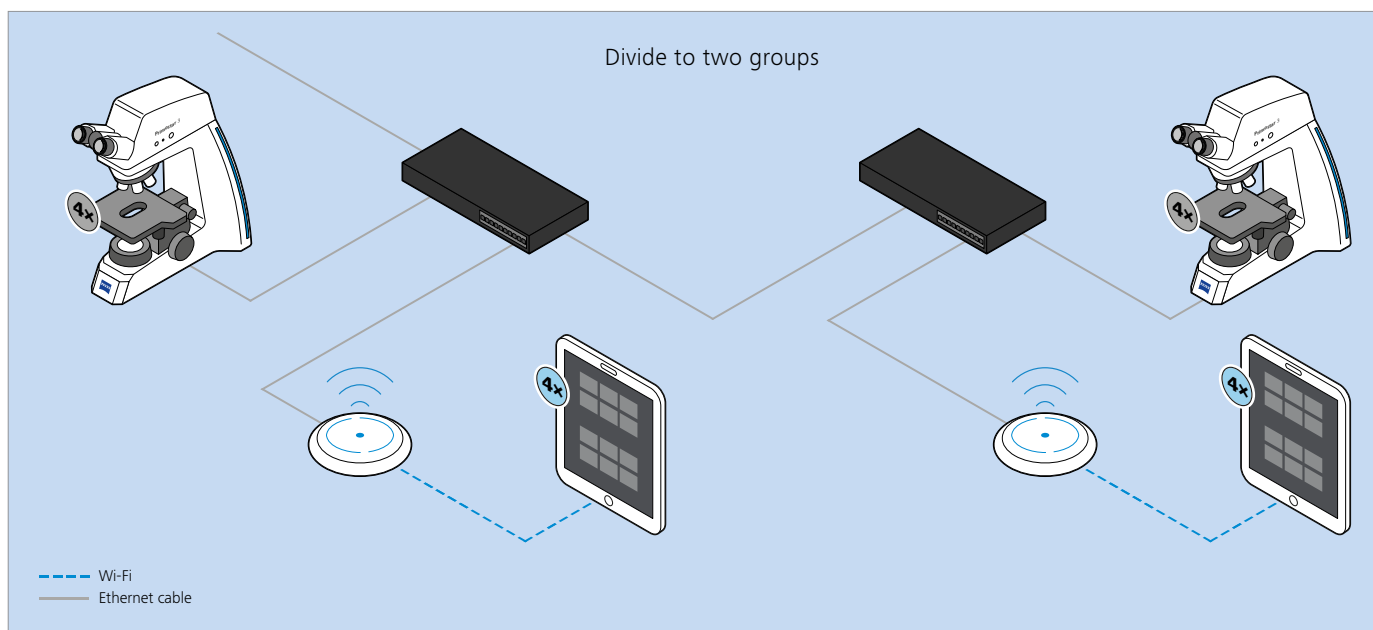


Note: The illustrated layout is for your reference. Please consider and implement according to the actual situation and requirements of your digital classroom.

For the groups with over 8 Primostar 3 HD and 8 tablets, to ensure a stable performance while 8 tablets are doing the snap at same time, $65 \text{ Mbps (snapping data rate)} \times 8 \text{ (number of tablets)} \times 2 = 1040 \text{ Mbps}$ is required for the bandwidth between switch and AP. Therefore, you could use the AP with 100/1000/2500M port and connect to the 10GbE port of switch via a CAT-7 cable. The other connected ports and cables can be still 1GbE and CAT-6.



There is also alternative solution to not upgrade IT devices for such groups. It is to divide the group into smaller groups by adding additional switch and AP. Then each separated group has less bandwidth requirement, and you could still use CAT-6 cable and 1GbE ports for all connections. Please see below illustration.



Note: The devices “group” here can also refer to the physical layout of classroom, e.g. a bench contains 8 microscopes and 8 tablets. You could also put two smaller groups on one bench for example. Please define and divide the groups according to your actual situation.

8.4 Example of big digital classroom with 50 microscopes and 50 tablets

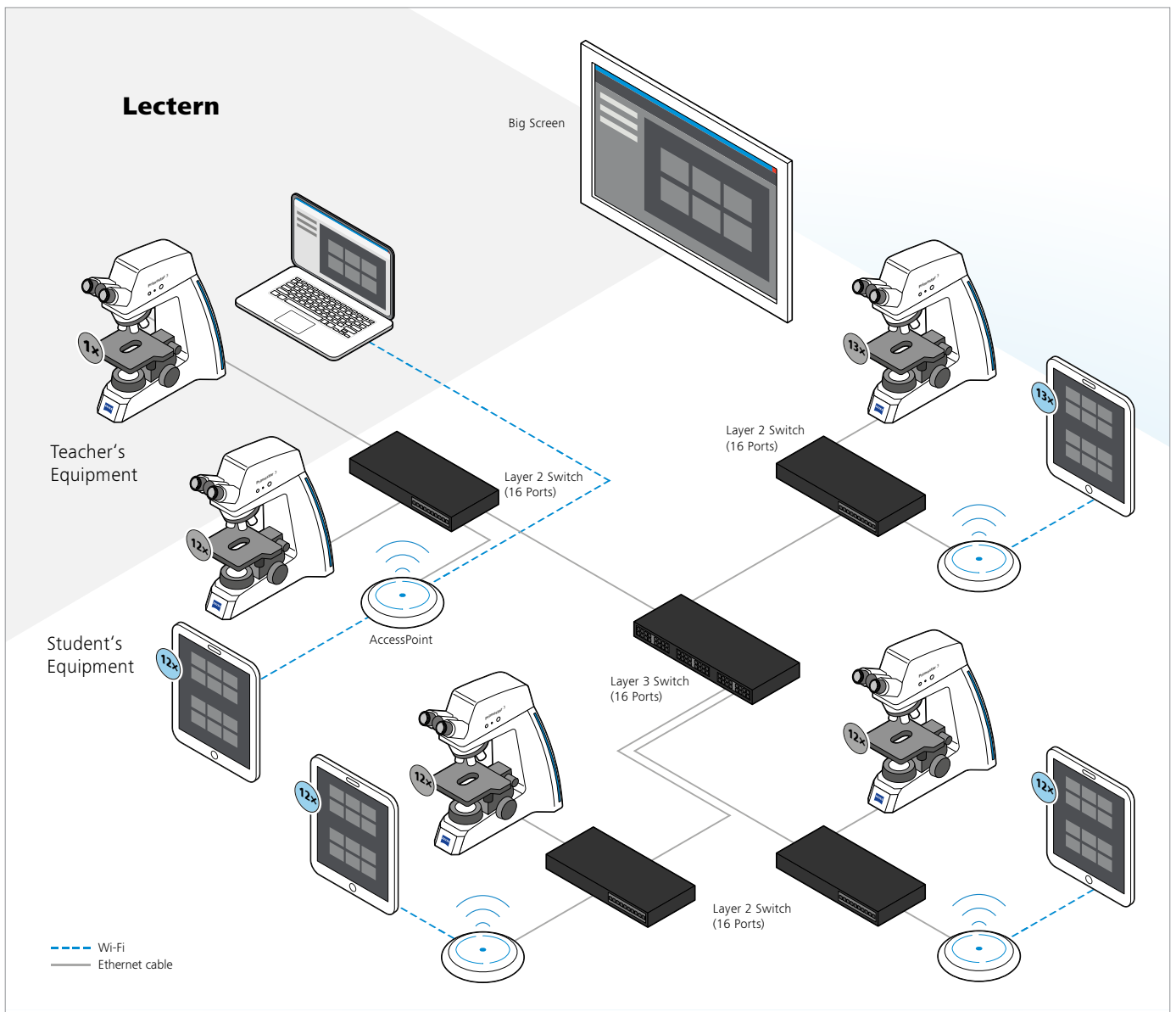
Here the microscope Primostar 3 HD is used for examples.

Required Wi-Fi bandwidth / data rate:

65 Mbps (snapping data rate) × 50 (number of tablets) × 2 = 6,500 Mbps

- For big digital classroom, the **combination of layer 3 switch, layer 2 switches and APs** are recommended.
- **Four APs** with **each** over **2,000 Mbps** Wi-Fi capacity @ 5GHz would be OK.
- Totally you need more than **54 LAN ports** (50 microscopes + 4 APs), you could use a 16 ports layer 3 switch plus 4 additional 16 ports layer 2 switches.

Note: For this case, you need to use the AP with 100/1000/2500M port and connect to the 10GbE port of switch via a CAT-7 cable. Or you can divide the group into smaller groups without changing AP and cable type. Please see the explanations in P. 13.



Note: The illustrated layout is for your reference. Please consider and implement according to the actual situation and requirements of your digital classroom.

8.5 Example of huge digital classroom with 100 microscopes and 100 tablets

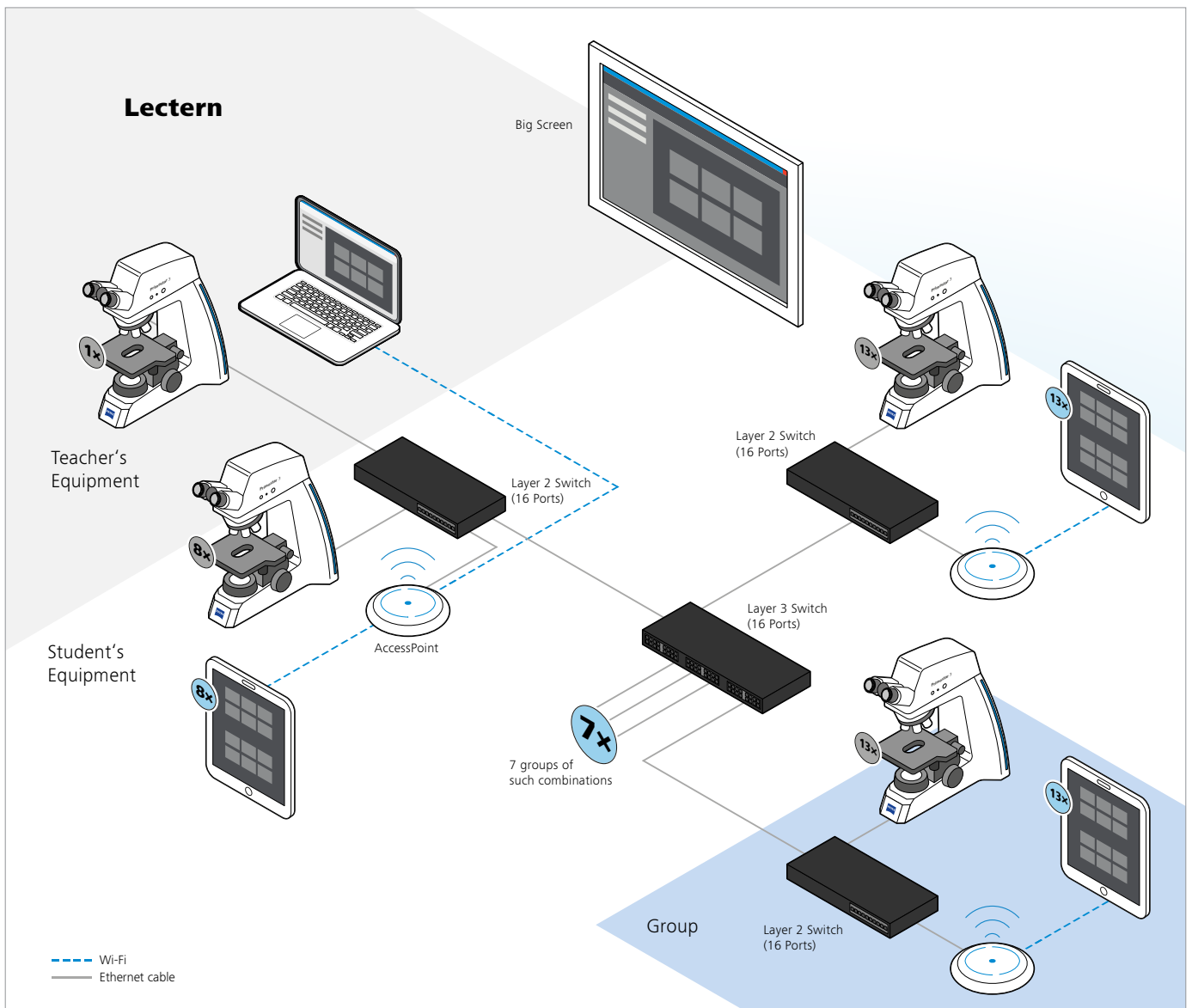
Here the microscope Primostar 3 HD is used for examples.

Required Wi-Fi bandwidth / data rate:

65 Mbps (snapping data rate) × 100 (number of tablets) × 2 = 13,000 Mbps

- For huge digital classroom, the **combination of layer 3 switch, layer 2 switches and APs** are recommended.
- **Eight APs** with each over **2,000 Mbps Wi-Fi capacity @ 5 GHz** would be OK.
- Totally you need more than **208 LAN ports** (200 microscopes + 8 APs), you could use a 16 ports layer 3 switch plus additional eight 16 ports layer 2 switches.

Note: For this case, you need to use the AP with 100/1000/2500M port and connect to the 10GbE port of switch via a CAT-7 cable. Or you can divide the group into smaller groups without changing types of AP and cable. Please see the explanations in P. 13.



Note: The illustrated layout is for your reference. Please consider and implement according to the actual situation and requirements of your digital classroom.

8.6 Example of huge digital classroom with 100 microscopes and 200 tablets

Here the microscope Primostar 3 HD is used for examples. Please note here the example has 200 tablets which is 2:1 to the number of microscopes. Therefore, we need to use the calculation method from [7.2 For the case that the device ratio of tablets to microscopes is more than 1:1. P. 9]

Required Wi-Fi bandwidth / data rate:

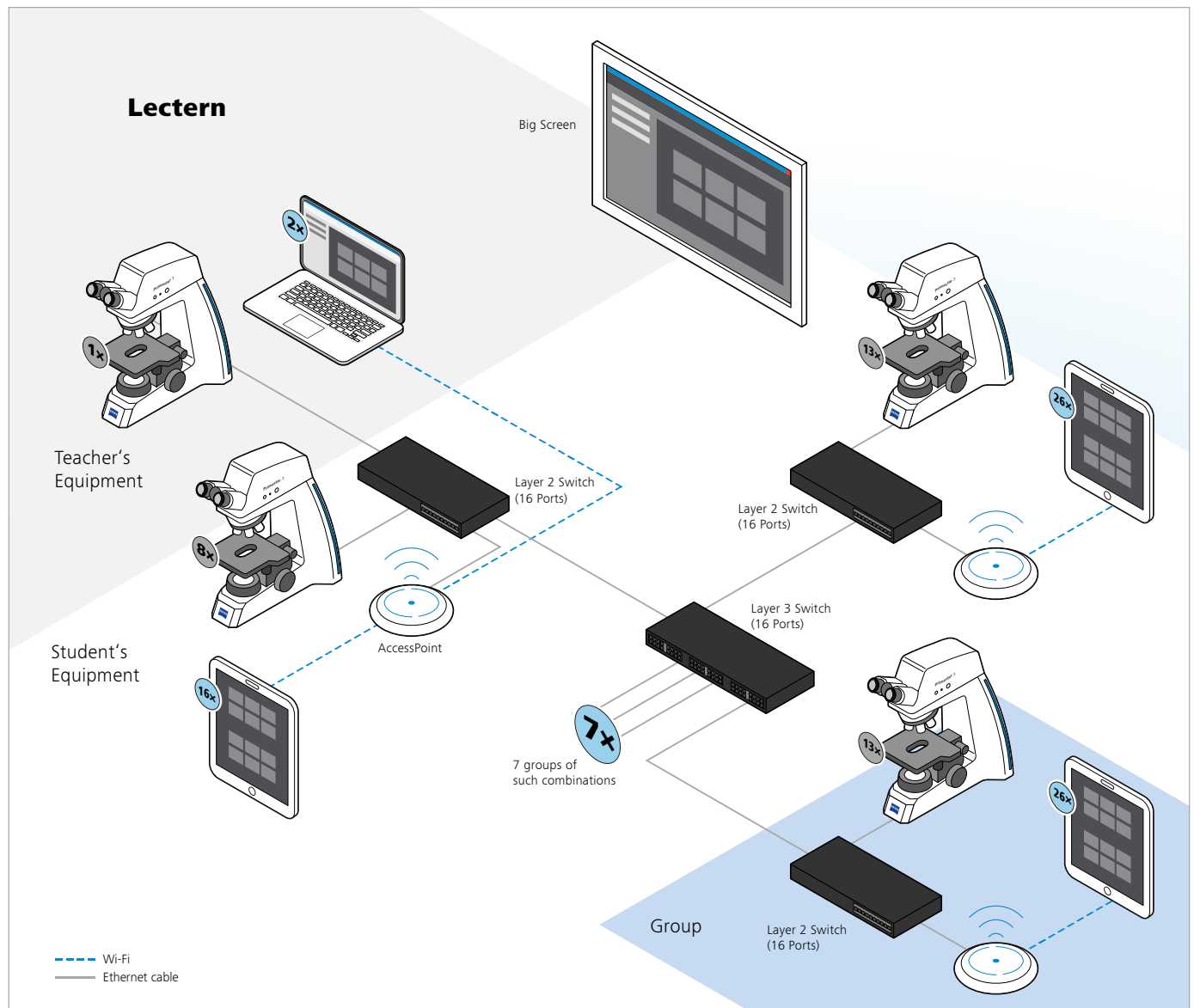
$65 \text{ Mbps (snapping data rate)} \times 100 \text{ (number of tablets)} \times 2 + 8 \text{ Mbps (live data rate)} \times (200-100) \text{ (number of tablets - number of microscopes)} \times 2 = 14,600 \text{ Mbps}$

- **Note!** For a classroom in a certain scale, division of VLANs or subnets are necessary for providing enough IP addresses and avoiding broadcast traffic. For tablets under different VLANs or subnets with the microscopes, you will need to use the

“Manually Add a Microscope” function for establishing the connection. Please see [4.1 Recommended IT conditions for digital classroom case without Labscope Teacher server, P. 6]

- For huge digital classroom, the combination of layer 3 switch, layer 2 switch and APs are recommended.
- 8 APs with each over 2,000 Mbps Wi-Fi capacity @ 5 GHz are still fine for this case.
- And this example uses a 16 ports layer 3 switch plus additional eight 16 ports layer 2 switches.

For this case, you need to use the AP with 100/1000/2500M port and connect to the 10GbE port of switch via a CAT-7 cable. Or you can divide the group into smaller groups without changing types of AP and cable. Please see the explanations in P. 13.



Note: The illustrated layout is for your reference. Please consider and implement according to the actual situation and requirements of your digital classroom.

To set different VLANs, you could set each group to different VLAN. Then inside each VLAN, students' tablets can automatically discover each other's microscopes within the group. That means each group is like to be isolated and in accord with the physical bench in the classroom. Thus, the students are not confused by seeing so many microscopes and the network traffic is more under control. Students can even set "Only use this microscope" in Labscope to furtherly reduce the network traffic. Please see in [3. An overview of different wireless connection ways, P. 5] for how to set the "Only use this microscope". For teachers, they can manually add IP addresses of the microscopes

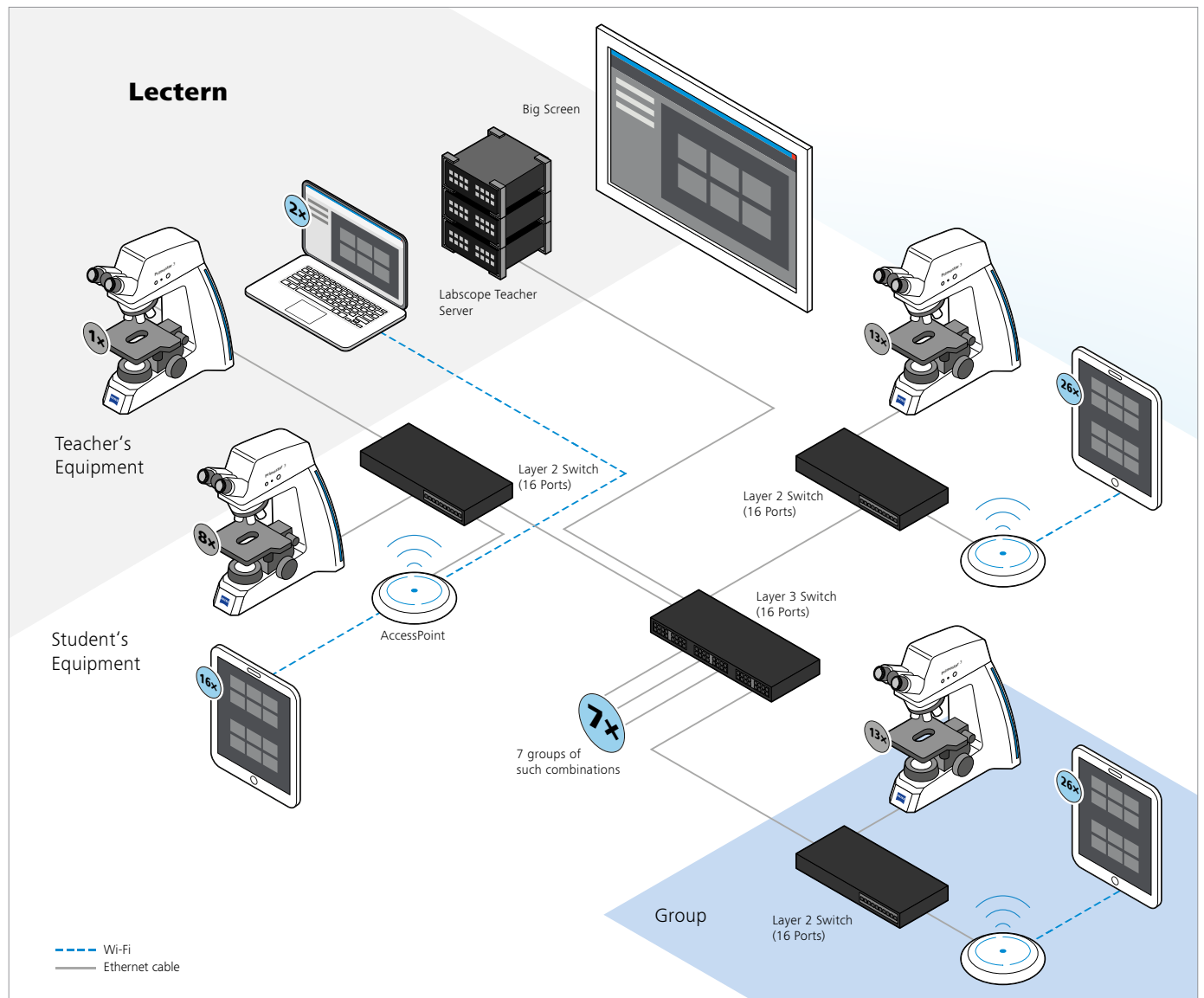
which are not in same VLAN with teachers' tablets. See in [4.1 For digital classroom case without Labscope Teacher server, P. 6]. Then teacher can see all microscopes in the classroom, students can only see their own microscopes.

Please note students can also manually add IP of microscopes in Labscope to establish the connection with microscopes from other groups. If you want to restrict this situation and have higher level authorization management, Labscope Teacher is the right tool to manage the access rights, microscope control ability and Labscope functions.

9. Example of digital classroom with Labscope Teacher

Here we use the last example of huge digital classroom with 100 microscopes and 200 tablets for the illustration of the case with Labscope Teacher. Please note the Labscope Teacher is also applied to different sizes of classrooms, from small to huge.

- The bandwidth calculation is same as the case without Labscope Teacher. Please refer to the [8.6 Example of huge digital classroom with 100 microscopes and 200 tablets, P. 16]



Note: The illustrated layout is for your reference. Please consider and implement according to the actual situation and requirements of your digital classroom.

- The layout is quite similar as well, just need to add one Labscope Teacher server into the main router (here it is the layer 3 switch in the example).
- **Note!** For the situation with different VLANs or subnets, the Labscope Teacher server and all microscopes must be in one VLAN and subnet. Please see [4.2 Recommended IT conditions for digital classroom case with Labscope Teacher server, P. 6]

For this case, you need to use the AP with 100/1000/2500M port and connect to the 10GbE port of switch via a CAT-7 cable. Or you can divide the group into smaller groups without changing types of AP and cable. Please see the explanations in P. 11.

To set different VLANs, as mentioned the Labscope Teacher server and all microscopes must be in one same VLAN and subnet, therefore the "group" concept is not proper here for

splitting the VLANs, since the group concept contains certain number of microscopes and tablets. You could consider to set one VLAN for Labscope Teacher server and mics, and all tablets are put to other VLANs.

After setting proper VLANs, the IP address of Labscope Teacher server needs to be added into Labscope on tablets to establish the connection. Please see [4.2 Recommended IT conditions for digital classroom case with Labscope Teacher server, P. 6].

10. System requirements

System requirements for Labscope.

System requirements	Labscope for Android*	Labscope for iPhone*	Labscope for iPad	Labscope for Windows
Operating system	Android 9.0 or later	iOS 13 or later	iOS 13 or later	Windows 10 (64-bit)
Minimum hardware	RAM: 4 GB	iPhone 6s / plus iPhone SE (2016)	iPad Air 2 iPad 5 iPad Mini 4	CPU: i3 (6 th generation) dual-core @ 2.5 GHz RAM: 4 GB
Recommended hardware	RAM: 6 GB or above	iPhone 7 or later	iPad Air 3 or later iPad 6 or later iPad Mini 5 or later iPad Pro 1 or later	CPU: i5 (7 th generation) quad-core @ 3.0 GHz or above RAM: 8 GB or above

***Note!** Labscope for Android and iPhone only supports the classroom case without Labscope Teacher.

System requirements for Labscope Teacher server.

System requirements	Labscope Teacher (≤ 8 microscopes)	Labscope Teacher (≤ 30 microscopes)	Labscope Teacher (> 30 microscopes)
Operating system	Windows 10 64-bit, Windows 7 64-bit, Windows Server 2012, Windows Server 2016		
Minimum hardware	CPU: i3 (6 th generation) dual-core @ 2.5 GHz RAM: 4 GB	CPU: i5 (7 th generation) quad-core @ 3.0 GHz RAM: 8 GB Network interface: Gigabit wired network card	CPU: i5 (8 th generation) quad-core @ 3.0 GHz RAM: 16 GB Network interface: Gigabit wired network card
Recommended hardware	CPU: i3 (8 th generation) dual-core @ 2.5 GHz or above RAM: 8 GB or above	CPU: i5 (9 th generation) quad-core @ 3.0 GHz or above RAM: 16 GB or above Network interface: Gigabit wired network card	CPU: i7 (10 th generation) quad-core @ 3.0 GHz or above RAM: 16 GB or above Network interface: Gigabit wired network card

11. FAQs

Q: Can Labscope connect to more than one microscope/camera at the same time?

Answer: Yes, within a LAN network, Labscope will discover the supported microscopes/cameras and establish the connection automatically.

Q: What is the maximum number of microscopes/cameras with connected phones/tablets/laptops for a digital classroom?

Answer: The network performance of your lab/classroom is one of the main factor for determining the number of ZEISS Microscopes and Labscope devices you can hook up. Labscope is built to handle more than one hundred microscope cameras simultaneously. With the right network layout even the largest classrooms and labs can be handled. The required bandwidth calculation and classroom layout examples in this guide provide more information on this topic. Please also consult with IT specialist and application engineers.

Q: What is the maximum number of Labscope devices to be connected to one microscope camera simultaneously?

Answer: This depends on camera types, connection ways, your network performance and network environment. For just connecting to several Labscope devices simultaneously, using the Wi-Fi adapter (if the camera supports) as the connection way is OK. For larger scale of connection, using Ethernet cable through a Wi-Fi router can support for seeing dozens of Labscope devices or even more simultaneously. Again, this has many interference factors. Please see [3. An overview of different wireless connection ways. P. 5]

Q: How to establish a remote education or remote lab?

Answer: Teacher or lab administrator uses PC/Laptop or tablets to connect to microscopes with Labscope and can easily share the screen to students or other colleagues who are at home or other places via Skype, Zoom, Microsoft Teams or other platforms. Connecting to multiple microscopes at same time and teacher/administrator can switch between different live images. Except for sharing the live view, teacher or administrator can also do the measurement, annotations, comparisons, image processing, reporting and sharing the result directly in Labscope.

Q: How to find the Laser Pointer and Drawing function in Labscope?

Answer: In global settings, go to the module manager and activate the "Education" module, then restart Labscope and the functions of Laser Pointer and Drawing will be shown up in the main toolbar.

Q: How can I change the storage destination of images in Labscope?

Answer: Labscope for iOS and Android only provides default storage path and cannot be changed by users. Labscope for Windows provides the function that user can easily choose the file storage path by clicking on the path in Files view.

Q: How can I share my files between Windows and iOS devices?

Answer: By using Apple's "Files" App (a native pre-installed App after iOS 13), you could easily create a folder connection to a shared folder of Windows device. Here are the steps: open the "Files" app in iOS device, click on the three dots on the top, and click on "connect to server", input the IP address the Windows device you want to visit, and click "connect". After finished, you can see the shared folder in the Files App of your iOS device. The above steps are only needed to be done for the first time. Then, in Labscope you can easily share the images to the folder by choosing "share", and "save to Files".

Q: How can I add and edit report template?

Answer: For Windows, please find the current report templates in C:\ProgramData\Carl Zeiss\Labscope3\ReportTemplates Then copy a template, rename it and open it to modify your own templates. The iOS version does not support the editing of templates yet.

Note:

For Service and support, visit [ZEISS Labscope Forum](#), which also includes the updated FAQs and release information.

For sharing your ideas of product development, visit [ZEISS Portal My Voice](#).



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