LabQuest 2 Networking

Advanced Technical Reference

Vernier LabQuest 2 is a standalone interface used to collect sensor data with its built-in graphing and analysis application. The large, high-resolution touch screen makes it easy and intuitive to collect, analyze, and share data from experiments. Its wireless connectivity encourages collaboration and personalized learning. You can also use LabQuest 2 as a computer interface using Logger *Pro* software for advanced analysis and video features.

This guide contains the technical details for the networking capabilities and services available in the LabQuest 2.

Contents

LabQuest 2 Hardware Specifications
- 800 x 480 pixel color display with resistive touchscreen
- 800 MHz ARM Processor
- Wi-Fi 802.11 b/g/n (2.4 GHz only)
- Bluetooth
- Built-in GPS, 3-axis accelerometer, ambient temperature sensor, light sensor, and microphone
- USB port for sensors, flash drives, and peripherals such as network adaptors
- USB mini port for PC connectivity
- MicroSD/MMC slot
- Rechargeable, high-capacity battery
- 3 analog sensor ports
- 2 digital sensor ports

The LabQuest software is updatable. We release software updates approximately twice a year that contain bug fixes and new features, these updates are free. Over the years things have changed slightly, this document describes the software as of 2.5.3. The updates, (and the instructions for installing them,) can be found here:
http://www.vernier.com/support/updates/labquest/labq2/

More up-to-date technical information may be available our web site at:
https://www.vernier.com/til/2694

Network Enabled Features

The networking capabilities of LabQuest 2 provide unprecedented tools for collecting and analyzing data on mobile devices, remote viewing/control of LabQuest 2 with a computer, and emailing sensor data and graphs for later analysis at home. These student-centric tools enable teachers to encourage collaboration among students with individual accountability. For an overview of these features, see the video at:

http://www.vernier.com/training/videos/play/?video=222&autoplay=true

Bonjour/ZeroConf

The LabQuest 2, LabQuest Viewer, and Graphical Analysis for iPad all support zeroconf (zero configuration) networking also referred to as Bonjour. This capability is used by the LabQuest 2 to automatically join networks and for applications or mobile devices to easily find LabQuest 2 devices on the network.

IP Address

After joining a network the LabQuest 2 will attempt to contact a DHCP server to obtain an IP address. If that attempt times out, a random IPv4 link-local address will be generated in the 169.254.0.0/16 range (link local addresses) using the device's MAC address as a seed. If the generated IP address is being used by another device, a new random IP address is generated until an unclaimed one is found.

On some networks that do not have any form of dynamic address allocation, the clients are all manually assigned an IP address instead of utilizing self-assigned addresses. In this case, the LabQuest 2 with a self-assigned IP may not be in the same subnet as the other devices on the network and will not be able to communicate. However, a correct networking configuration can be easily specified on the LabQuest.

Manually Configuring the Network Connection Settings on the LabQuest 2
1. Tap Connections from the main screen.
2. Tap the gear in the upper right of the Connections screen.
3. Tap the gear in the upper right of the Network selection screen.
4. Go to the configuration tab.
5. Select Manual.
6. Enter the IP address, netmask, and gateway appropriate for your network.
7. Tap Save.

To return to the default behavior of self-assigning an IP address, select Automatic from the dialog in step 4.

How to Determine the IP Address Used by a LabQuest 2
1. Tap Connections from the main screen.
2. The IP address currently being used by the LabQuest 2 will be displayed in the lower left under the QR code.

Multicast DNS (Bonjour)

Applications such as LabQuest Viewer, Graphical Analysis for iPad, and web browsers on devices that support Bonjour can find LabQuest 2 devices by automatic discovery or entering the LabQuest's hostname. This capability utilizes Multicast DNS (mDNS) for both service discovery and hostname resolution.

mDNS uses IP multicast networking over UDP to provide DNS host lookup and service announcement without the need for a traditional DNS server. This capability requires multicast support from the network which is sometimes disabled by administrators for security reasons. Typically multicast traffic cannot traverse subnets due to gateway configuration meaning that clients of subnet A cannot discover LabQuest 2 devices on subnet B.

mDNS Protocol Detail
- mDNS traffic is sent to MAC address 01:00:5E:00:00:FB
- The multicast IPv4 address is 224.0.0.251
- Traffic is sent to UDP port 5353

If you are selectively blocking Bonjour strings, the service strings that the LabQuest 2 uses are:

_vernier-data._tcp.local.   (for Data Sharing/Graphical Analysis)
_labquest-rfb._tcp.local.   (for the LabQuest Viewer.)

If mDNS discovery or name resolution is failing on your network, make sure that your switches and other network equipment support multicast traffic, there are no firewall rules blocking 224.0.0.251 or UDP port 5353 and your device is on the same subnet as the LabQuest 2.

The hostname of a LabQuest 2 device is the device's name (default name is LabQuest) without spaces appended by the .local domain.

Example: A LabQuest 2 named Classroom A will have a hostname of ClassroomA.local

How to Set the Hostname of a LabQuest 2
1. Tap Connections from the main screen.
2. Tap on the gear to the right of the Name box.
3. Enter a new name for the LabQuest 2.
4. Note the HostName displayed in the Device Information section of the screen.

Data Share
Devices can poll sensor data wirelessly from a LabQuest 2 interface through Vernier Data Share. Using a compatible app or web browser, students collaboratively collect experiment data and analyze an individual copy of the data on their own device. The simplest choice is to use the Graphical Analysis app, which is a free download for Mac, Windows, iOS, Android, and Chrome at:
https://www.vernier.com/product/graphical-analysis-4/

The Data Share service is an HTTP server accepting requests on TCP port 80 that runs on the LabQuest 2.

1. From the main screen tap Connections.
2. Tap on the gear to the right of the Data Sharing box.
3. Select either On or Off.
4. If you wish to allow remote devices to start/stop data collection, check the box at the bottom of the screen; otherwise uncheck the box

In the lower left of the Connections screen is the URL for the Data Share service. Local devices can connect to the LabQuest in a web browser. A QR code is also provided which can be used by devices with QR code support to automatically open a browser to the IP-based URL.

To use Data Share in a web browser, updated web browsers are required because it uses HTML5 features. In an unsupported web browser, Data Share will be unusable. The latest version of all major web browsers is supported on all major platforms, but earlier web browsers may have issues.

Sending Email

LabQuest 2 can email sensor data in multiple formats, depending on the needs of the student and experiment. Students can email sensor data to their own email addresses to continue lab reports at home, or to submit to the instructor. The LabQuest 2 can only be used to send an email with the following attachments and cannot be used to receive email.

Email Data Formats
- **Data File**: A .qmbl file is attached to the email for import into Logger *Pro* for analysis
- **Graph**: A PDF of only the graph portion of the LabQuest App is attached to the email
- **Text File**: A TXT file is attached to the email for importing into spreadsheets
- **Screen Shot**: A PNG image is attached to the email

The LabQuest 2 supports open SMTP servers, SMTP servers that use PLAIN authentication, and SMTP servers that use TLS authentication.

How to Configure an SMTP Server on LabQuest 2
1. From the Home screen tap Connections.
2. Tap on the gear to the right of Email.
3. Turn on Email support by selecting On.
4. Enter the server name of your SMTP mail provider (e.g. smtp.gmail.com)
5. If the server requires a secure TLS connection select the Use TLS checkbox.
6. The network port will default to 25 for plaintext SMTP and 587 for TLS SMTP, if your SMTP server uses a different port enter it.
7. If your SMTP server requires a username and password for authentication, enter them. Some servers require a username while others only require a From email address for the user.
8. Enter the From address.
9. Tap the OK button.

The Test button at the bottom of the email setup dialog will send an e-mail to the From address. When users are actually sending e-mail, they'll be able to type in the destination addresses. Reset clears all the fields in the dialog.

  ● Make sure the LabQuest 2 is connected to a network with access to the SMTP server
  ● Verify that the port, servername, and authentication settings are correct for your SMTP server
  ● Verify that the username or email and password are correct for your SMTP server
  ● Make sure the SMTP server does not block emails with attachments
  ● Some of the attached data tables can be large and the resulting email might be blocked by the SMTP server
  ● Try setting the From address in step 8 above to a valid email address if it is blank

In cases where the SMTP server authentication is configured with a student's account, the student will wish to clear her credentials from the LabQuest 2 before another student uses the device.

For updated info about the e-mail options, see the "Using the LabQuest 2 Email Feature" section of:
https://www.vernier.com/til/2694

LabQuest Viewer

LabQuest Viewer software allows you to view and control the LabQuest wirelessly from your Windows or Mac computer or an iPad. When used in conjunction with a projector, you can share any LabQuest screen with the entire class. Share an instructor's screen for demos, or a student's screen for class presentations.

The LabQuest 2 contains an onboard VNC server that runs on TCP port 5900. The LabQuest Viewer software and VNC clients can connect to this VNC server to view and control the screen of the LabQuest 2. The ability to remotely control the screen can be disabled and the entire VNC server can be stopped if this feature is not desired. Additionally, the VNC session can be password-protected.

The VNC server can be accessed through any network to which the LabQuest 2 is connected including infrastructure wireless network, soft AP networks, and IP-over-USB.

Enabling or Disabling the LabQuest 2 VNC Server
  1. From the Home screen tap Connections.
  2. Tap the gear to the right of the Viewer.
  3. Turn the VNC Server on or off with the On/Off options.
  4. Choose to allow VNC clients remote control of the screen with the Allow screen control option.
  5. (Optional) Require a password for VNC access by selecting the checkbox and entering a password.
  6. (Optional) A channel can be set on the LabQuest 2 VNC server. In LabQuest Viewer, if a channel filter is specified, only LabQuest 2 devices that are using the channel specified will be shown in the host list. This is useful for settings where it is desirable to only show

LabQuest 2 devices from a certain classroom or group, ignoring all other LabQuest 2 devices on the network.

7. (Optional) If TCP port 5900 is blocked or otherwise unavailable on your network you can change the port on which the VNC server listens

By default the ability to connect to the LabQuest 2 VNC server over USB is disabled. This functionality can be enabled for cases where a LabQuest 2 is connected to a laptop via USB for presentations or demonstrations. Follow the instructions in the IP-over-USB section to enable USB support.

Printing

The LabQuest 2 supports HP printers connected via USB cable (USB-A to USB-B, NOT a mini-USB cable), or WiFi, however not all HP printers are compatible. A list of supported printers is available at: http://www.vernier.com/til/1659/

Adding a Printer to the LabQuest 2

1. From the Home screen tap Preferences.
2. Tap Printers.
3. Tap Scan for Printers.
4. Once the desired printer is found, tap the Install button.
4b. If it doesn't find the desired printer, Tap Enter IP Address or Name and then enter the IP Address of the printer.
5. If the device is compatible with the LabQuest 2 a list of available drivers will be displayed.
6. Select a driver.
7. Tap Install.

Wireless Networking

The LabQuest 2 can connect to 802.11 b/g/n Wi-Fi networks on the 2.4GHz spectrum using a built-in wireless chipset. An external USB Wi-Fi adapter may be used in place of the built-in chipset if necessary. The LabQuest 2 is able to connect to existing Wi-Fi networks that are either visible or have a hidden (non-broadcast) SSID. The LabQuest 2 can also create a separate soft-AP based network if no suitable Wi-Fi networks exist.

Some Wi-Fi networks utilize what is referred to as a captive portal. On these networks, until a device is registered with the network, all network traffic from that device is redirected to a web page where an account must be entered or terms accepted. The LabQuest 2 should detect when it has been joined to a network with a captive portal and present the user with the portal web page. However, this detection might not be compatible with all networking equipment in which case the MAC address of the LabQuest 2 can be added to the white list on the captive portal.

1. From the Home screen tap Connections.
2. Tap the gear in the upper right of the Connections screen.
3. Tap the gear in the upper right of the Network selection screen.
4. Go to the Device tab.
5. The MAC address for the current network adaptor is listed. For the built-in one, they all start with 00:C0:DF

Other Wi-Fi networks implement technology sometimes called isolation mode. This network configuration is popular on 'guest networks' where security is a concern. The isolation mode prevents any network traffic between client devices on the network. The only traffic permitted is between a device and the network gateway. In an isolation mode network, many of the network features of the LabQuest 2 will not be useful since devices trying to establish DataShare and LabQuest Viewer sessions will not be able to reach the LabQuest 2.

The LabQuest 2 can remember wireless network credentials like passphrases and username/ password combinations for each network configured. Each time the LabQuest 2 attempts to connect to a network for which credentials are stored, the remembered credential will be used. In order to change or remove remembered credentials, the LabQuest 2 allows saved credentials to be forgotten.

How to Forget Remembered Network Credentials
1. From the Home screen tap Connections.
2. Tap the gear in the upper right of the Connections screen.
3. Connect to the network for which credentials are saved.
4. Tap the gear in the upper right of the Network selection screen.
5. Tap Forget.

Wi-Fi Supported Network Types

The LabQuest 2 supports an array of different Wi-Fi network modes and configurations.

Open Networks

The simplest supported network configuration is an open network where no authentication or encryption is used.

WEP

Older network equipment might use a Wired Equivalent Privacy (WEP) security algorithm for authentication and encryption. The LabQuest 2 supports networks secured with WEP, however, WEP has been largely replaced by the more secure WPA protocol.

WPA/WPA2 Pre-Shared Key (PSK)

Wi-Fi Protected Access (WPA) and Wi-Fi Protected Access II (WPA2) improves on the relatively weak security of WEP and can be used in Personal, also known as Pre-Shared Key (PSK), or Enterprise configurations. WPA/WPA2 PSK is the simpler of the two configurations and is based around a network passphrase shared between the client and Wi-Fi router for authentication. The LabQuest 2 has full support for WPA/WPA2 PSK networks using either TKIP or CCMP(AES) encryption.

WPA/WPA2 Enterprise

Because distributing a network shared key to hundreds of users is infeasible, WPA/WPA2 also known as 802.1X, has an enterprise mode that supports multiple protocols and authentication mechanisms suitable for business and school environments. 802.1X can be used with a number of Extensible Authentication Protocol (EAP) types, however, the LabQuest 2 currently only supports PEAPv0/EAP-MSCHAPv2.

Connecting the LabQuest 2 to a Wi-Fi Network
1. From the Home screen tap Connections.
2. Tap the gear in the upper right of the Connections screen.
3. Make sure the Wi-Fi Radio is turned on selecting the "on" setting.
4. Select the desired Wi-Fi network from the list.
5. If the network requires a passphrase or key, enter it when prompted.
    > **Tip:** LabQuest supports standard USB keyboards, which may make typing a long passphrase easier.
6. (Optional) Adjust the Remember duration if you want the entered password to be remember for future connections to this network.
7. Tap Connect.

Connecting to a Wi-Fi Network with a Hidden SSID
1. From the Home screen tap on Connections.
2. Tap the gear in the upper right of the Connections screen.
3. Make sure the Wi-Fi Radio is turned on selecting the "on" setting.
4. Select Join Other Network... from the network list.
5. Enter the name of the desired network in the SSID box.
6. Select the security type for the network.
7. If the security type is not None enter the passphrase for the network or username and password for an enterprise network.
8. (Optional) Adjust the Remember duration if you want the entered password to be remember for future connections to this network.
9. Tap Connect.

Wi-Fi peer-to-peer Networks

The LabQuest 2 can establish a soft-AP based peer-to-peer, wireless network with classroom devices. This is ideal for Bring-Your-Own-Device environments where school network security is a concern or in situations where the school network is incompatible or unable to support LabQuest 2 networking.

Note that a soft AP network functions similarly to an adhoc network in that there is no internet connection, but it is not an adhoc network, it is "regular" network as far as client devices are concerned. As such, the LabQuest that creates the network handles things like handing out DHCP addresses (link local addresses aren't used,) and if that LabQuest gets turned off or goes out of range, the rest of the devices on the network get disconnected.

Creating a Soft AP Network on the LabQuest 2
1. From the Home screen tap Connections.
2. Tap the gear in the upper right of the Connections screen.

3. From the network list select Create Network...
4. Enter a name for the network, this name will display in the available networks list on other wireless devices.

Bluetooth

The LabQuest 2 has a built-in bluetooth adapter for connecting to bluetooth devices such as the Vernier Wireless Dynamic Sensor System (WDSS). Newer LabQuest 2s can also connect to BTSmart devices, such as the Go Direct products, (older units need an adapter.) You can identify the Bluetooth capabilities of the device here: http://www.vernier.com/til/3085/

Wired Networking

In addition to the built-in WiFi networking capabilities of the LabQuest 2, it can also use IP-over-USB. Primarily used with LabQuest Viewer running on a computer connected to a projector, IP-over-USB support can be enabled to allow the VNC server to communicate over a USB cable.

IP-over-USB

The IP-over-USB functionality causes the LabQuest 2 to appear as a USB Ethernet Gadget to the host PC when connected via mini-USB cable. The LabQuest 2 starts a built-in DHCP server that only listens to requests on the usb0 interface. The DHCP server is configured with a lease pool in the 192.168.234.10-100 range. **Note:** enabling this feature disables the ability to connect to Logger *Pro* or Graphical Analysis via USB.

Enabling IP-over-USB Support
1. From the Home screen tap Connections.
2. Tap on the gear to the right of LabQuest Viewer.
3. Check the Enable Viewer over USB checkbox.
4. Tap OK. (Note newer versions of the software do not require a reboot.)

Troubleshooting

Updated network troubleshooting is available at:

http://www.vernier.com/til/2669