

# Technical Challenges of Remote Access to Instruments Over Mobile Network

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# Introduction

- The more remote the location of a power quality monitor , the more it makes sense to have a network connection to it for remote control and data download
- Many remote locations are serviced by the mobile phone network
- Due to network architecture, it is not straight-forward to set up a network to a remote device
- A technical explanation of the challenges and two solutions will be described in this presentation

# Why Connect Remotely?

- Why would you want to connect PQ monitoring instruments to internet?
  - Remote monitoring (real-time status and values)
  - To receive alarms & warnings triggered by significant events
  - Remote configuration of instruments
  - Download data captured by instrument (Ex: Voltage and current waveforms from power quality monitors)



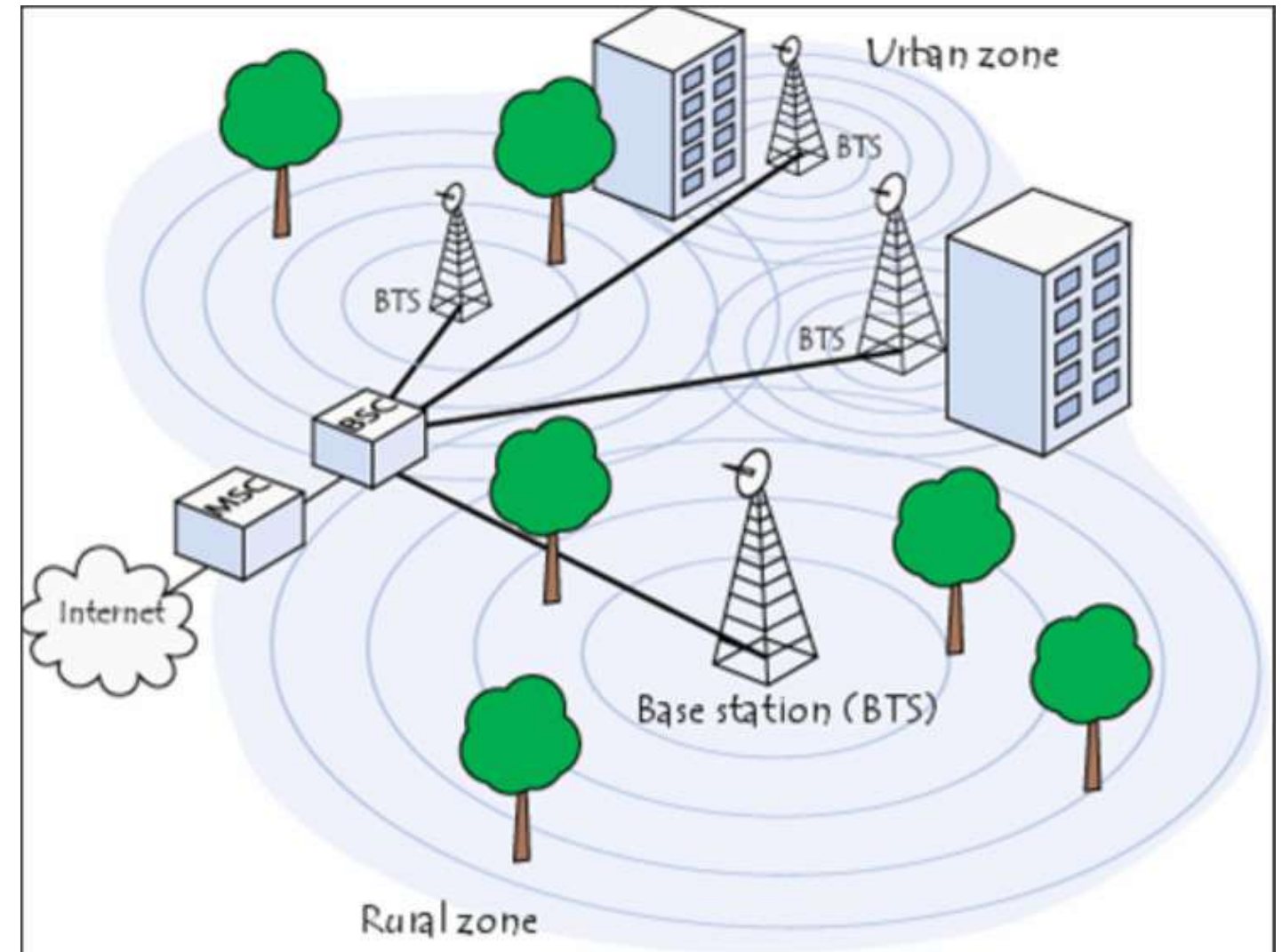
# Why Use the Mobile Phone Network?

- Power quality monitoring instruments located where no wired or WIFI Internet access
- Site has internet, but company IT policy prohibits connections due to security concerns
  - If PQ monitor is to be installed only for a short time, is it worth the time and paperwork to get permission from the IT department?
- An attractive solution is to connect via 3G/4G mobile network



# Mobile Network Architecture

- Base stations are transmitter-receivers that communicate with mobile devices
- Besides carrying voice, they carry data (i.e., Internet)
- Base stations are linked to the Internet by cable or fiber
- In remote location with no cable, microwave radio is used to transmit data to a site that is connected to the cable



# How a Network Connection is Initiated

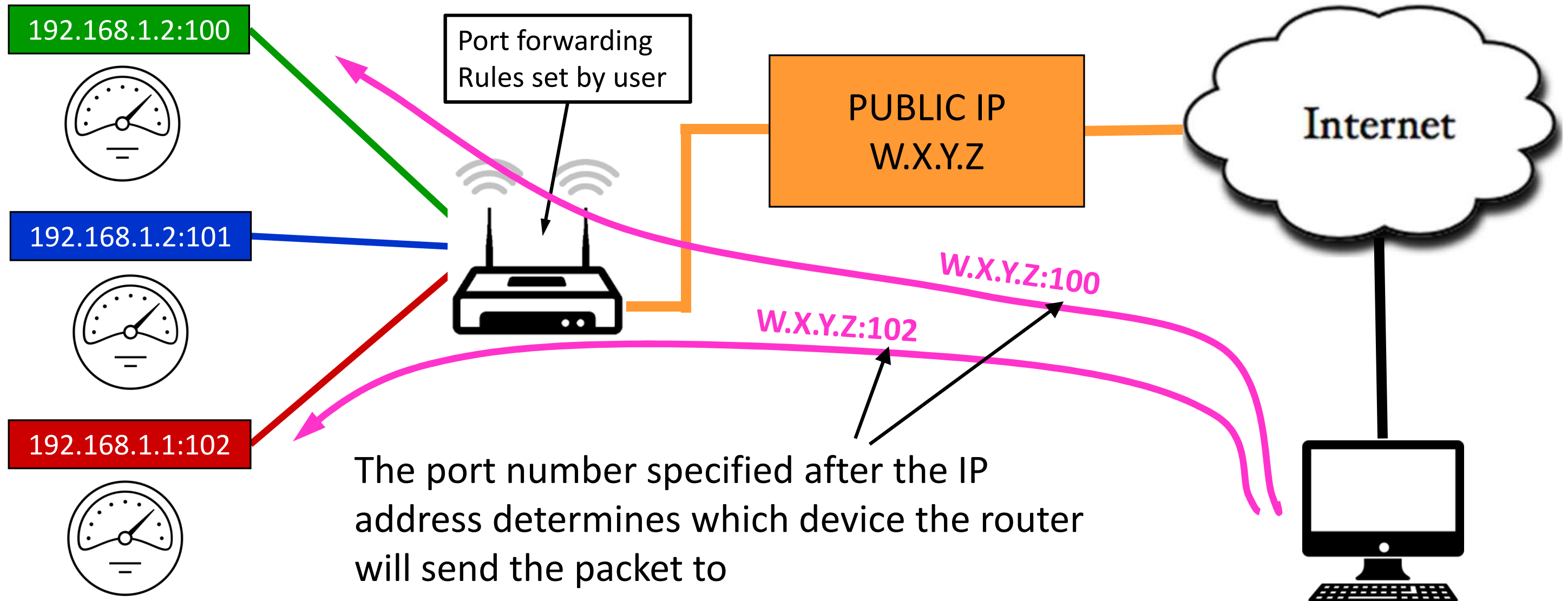
The following applies to two devices on any network, wired or not wired:

- Connection has to be initiated by at least one side
- The side initiating the connection must know the IP address of the other device
- Most remote devices can listen for incoming connection, but cannot initiate a connection
- User at base location must initiate the connection to remote device, usually by using a computer

# Port Forwarding

- Remote devices are usually behind a router, and share a single public IP address
- Example, Home IP camera, Media server, and maybe some other devices sharing a single Internet connection
- All incoming connections must be made to the same IP address
- How to rout the connection to the intended device? Port forwarding:
  - Each device listens on a unique port
  - Router is configured to send traffic to the respective device based on the port number specified in the incoming data

# Port Forwarding





# Port Forwarding And Mobile Network

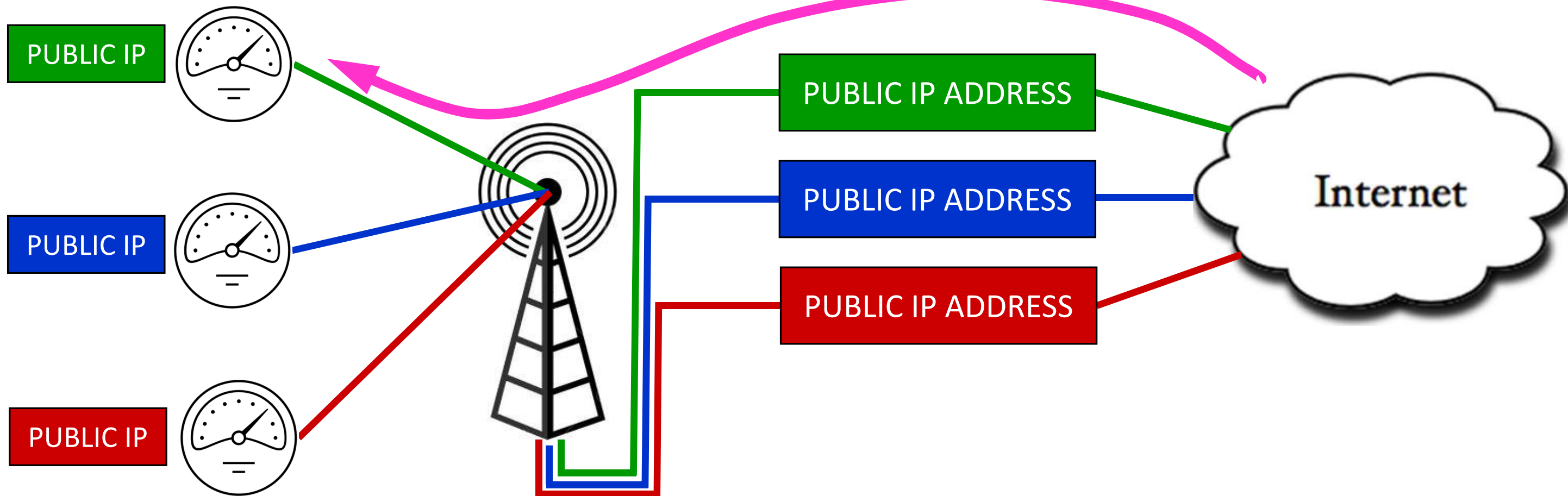
- On mobile network, also must use port forwarding if connecting more than one device to a single SIM card
- Need to supply your own router to do this
- If only a single device connected such as a phone, no need to forward ports. Connect directly to network and all ports should be visible
- Problem is, most mobile networks block traffic to incoming ports

# What is a NAT'ed IP Address?

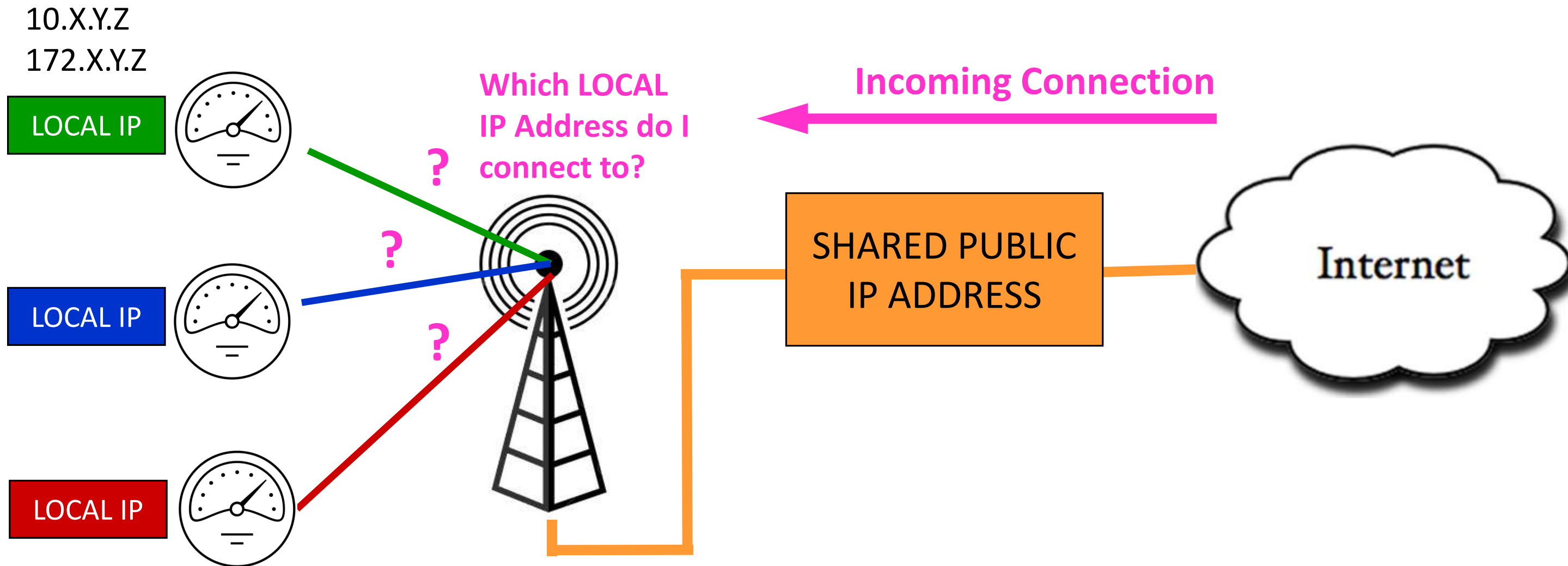
- NAT = Network Address Translation
- NAT involves sharing a Public IP address amongst more than one user of the mobile network
- Reasons they do this:
  - Not enough IPV4 public addresses
  - Mobile carriers (and everyone else too who connects to the Internet) has to pay for each Public IP address
  - Many mobile users, few Public IP addresses = big savings

# Public IP Addresses Illustrated

Incoming connection possible via PUBLIC IP



# NAT'ed IP Address Illustrated

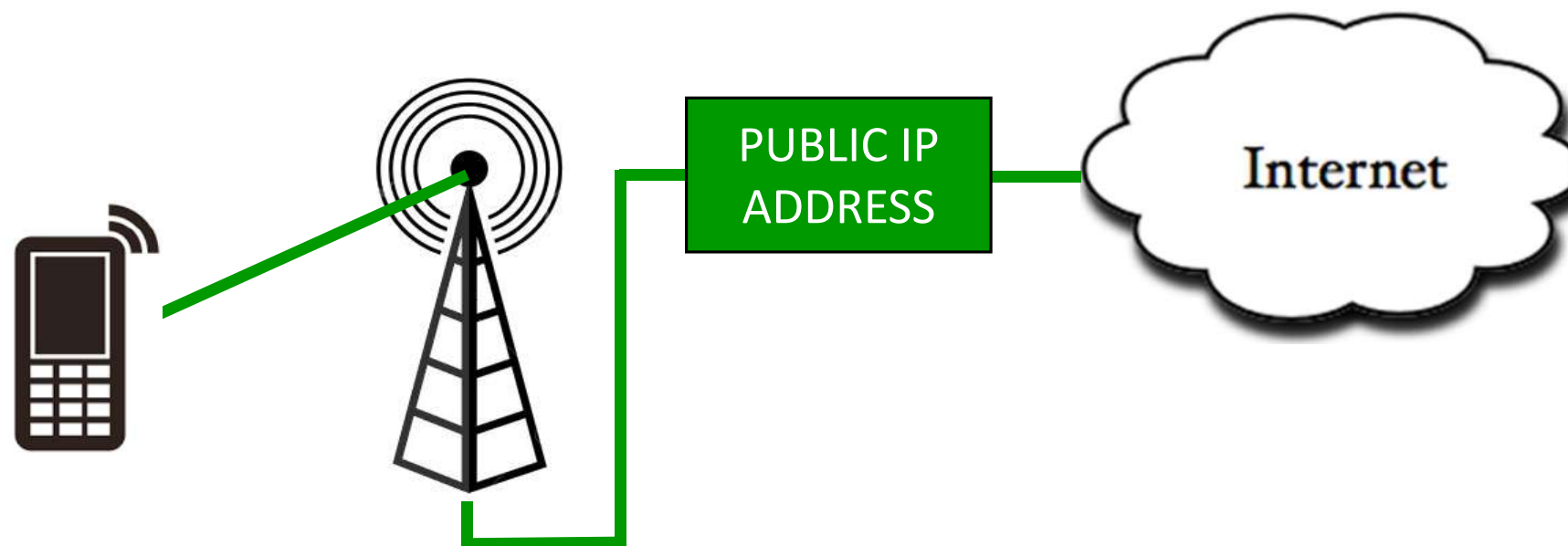


# Quick Check for NAT

- In NAT'ed system, the local IP addresses are usually in the form of "10.X.Y.Z" or "172.X.Y.Z".
- On your mobile phone, check your IP address <https://www.whatismyip.com/>
- If first number of IP address is 10, 172, or 192, address is NAT'ed
- Only sure way to tell is to try to connect to a port from an external IP address

# Request a Static Public IP Address

- Ideally, try to get mobile carrier to provide a public-facing and static IP address
- Connections very easy, just connect to the remote IP address!



# Dynamic Public IP Address

- A Dynamic IP address is one that is not static
  - Address changes every time a new connection is made
  - Dropped connections will also result in an address change after reconnection
- If carrier cannot provide static IP address, there is a simple solution:
  - Use DNS mapping service, such as DynDNS, No-IP, FreeDNS to map your dynamic IP address to a domain name

# Domain Name Mapping Service

- Sign up for service, create username and password
- Choose a domain name, example [myremote.dyndns.org](https://myremote.dyndns.org)
- Set the remote router to connect to the DNS service, login with username and password, and tell it its IP address
- Practically all routers support this, even the low-end home-use routers provided free by Internet provider

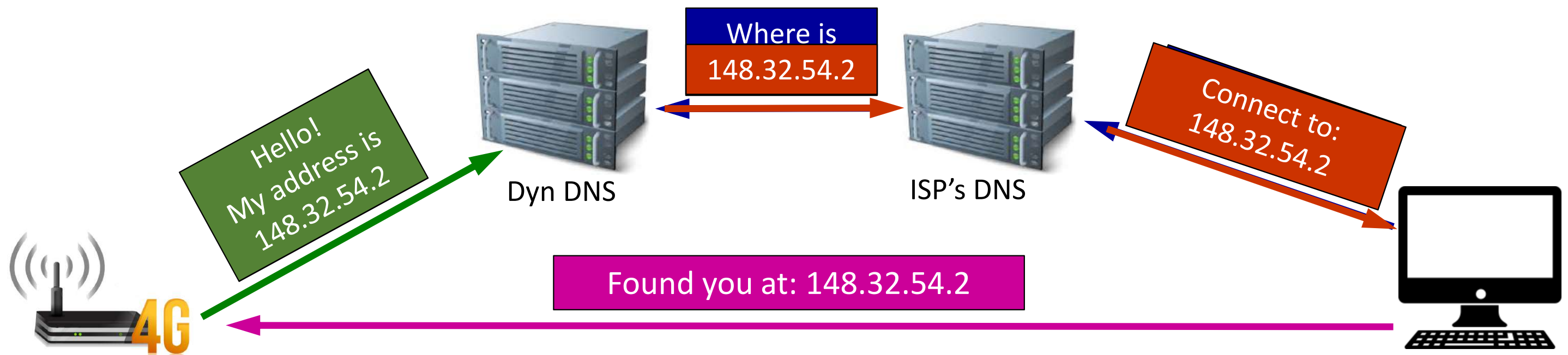


# Domain Name Mapping Service

- Whenever router detects IP Address change, it connects to service and updates it's new IP address
- To connect to remote, use the DNS name instead of IP address
- Example: <http://myremote.dyndns.org>

# Domain Name Mapping Service

1. Router sends its latest IP address to Dynamic DNS server
2. User initiates connection by using DNS name
3. ISP's DNS server requests IP address from Dynamic DNS server
4. Reply with IP address and passed on to user's computer
5. Connect directly to remote

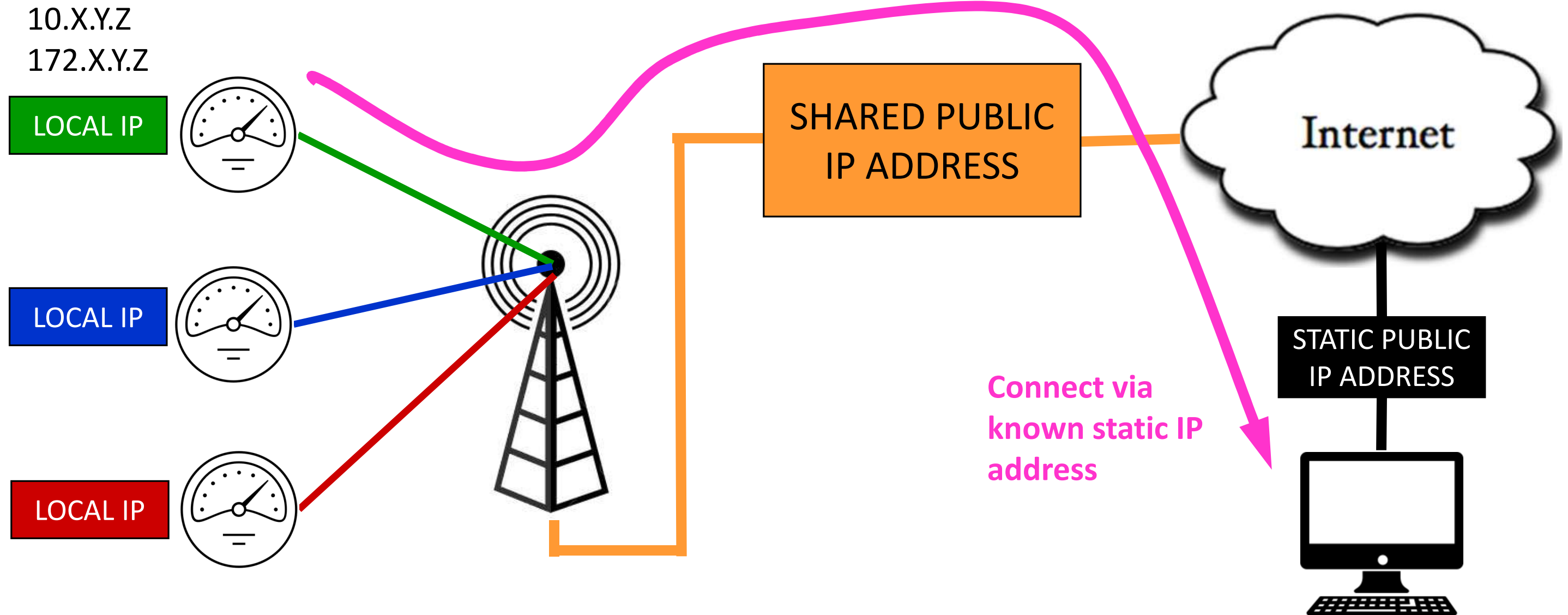


# Request a Public IP Address

- Some mobile carriers will provide a public-facing IP address at extra cost
- In Thailand, they do not. We asked:
  - AIS, DTAC, True
- In this case, it is impossible to connect to a remote device, so the solution is to get the device to “phone home”



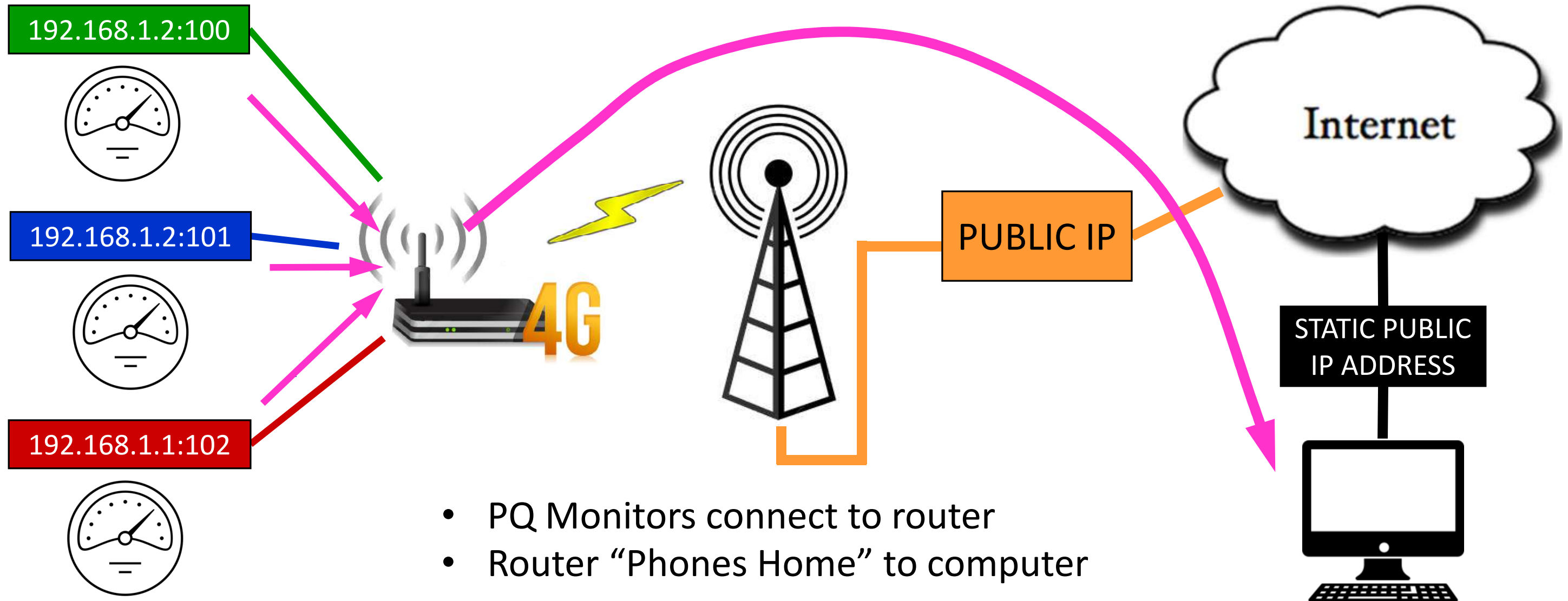
# PQ Monitor "Phone Home"



# PQ Monitor “Phone Home”

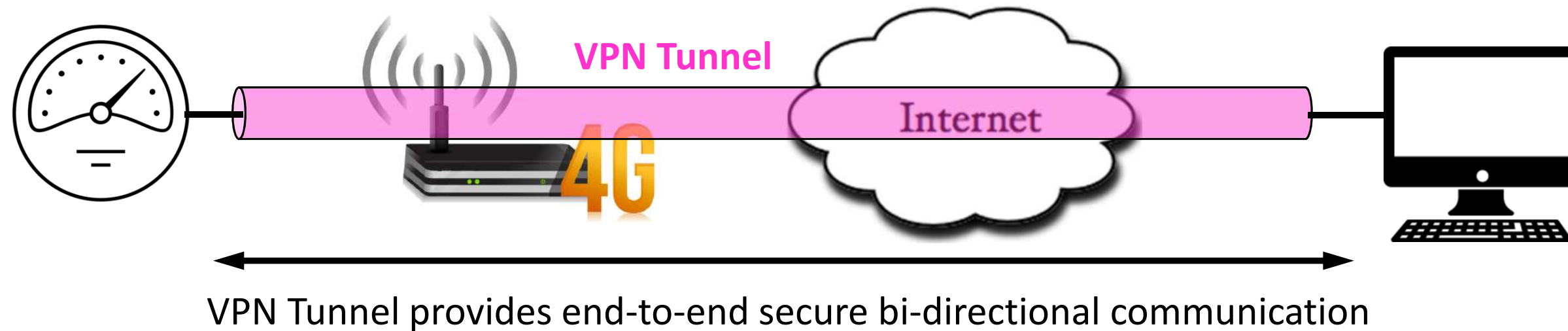
- Most power quality monitors do not have the ability to “phone home” implemented in their software
- This is why a “smart” 3G/4G router is needed
- It will “phone home” and establish a VPN connection with the base location
- Base location now connect through the router to the PQ monitor

# Router “Phone Home”



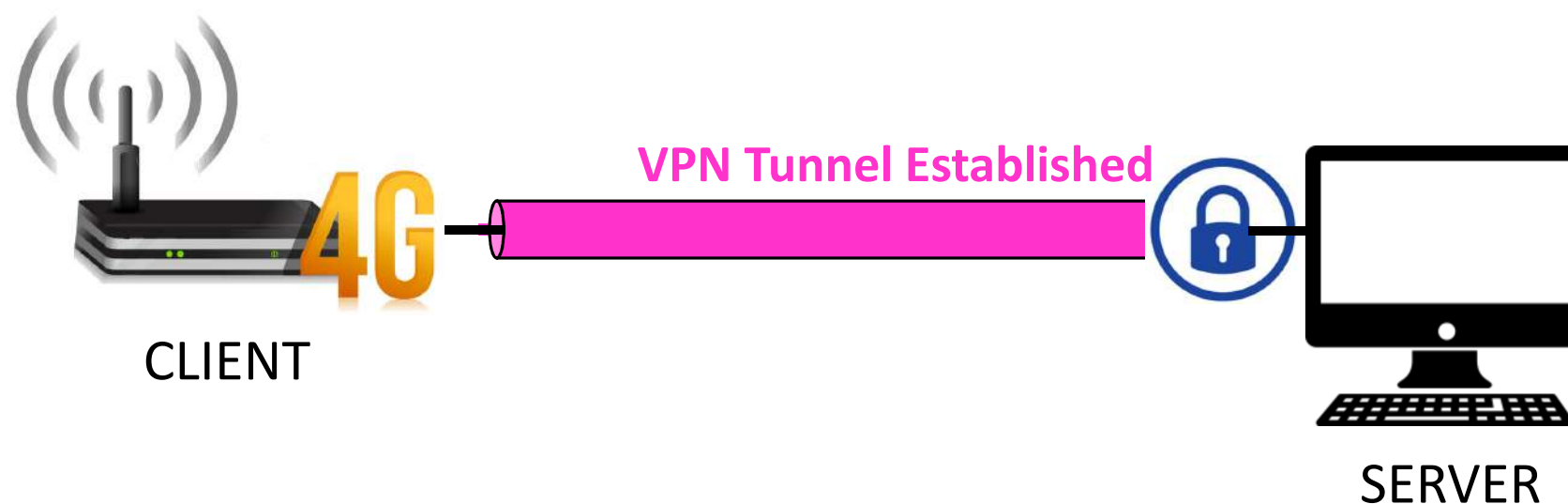
# Establish a VPN Connection

- Router then establishes a VPN (Virtual Private Network) connection
- Encrypted, secure connection
- Remote device is visible to computer as though it were on the local network
- Access remote device using IP address assigned by the VPN



# Client-Server VPN Connection

- Client-Server Direct connection
  - VPN client contacts a VPN server
  - Server requests authentication (username+password, or certificate)
  - If Client authentication passes, VPN connection is made
  - Client and server are both accessible to each other





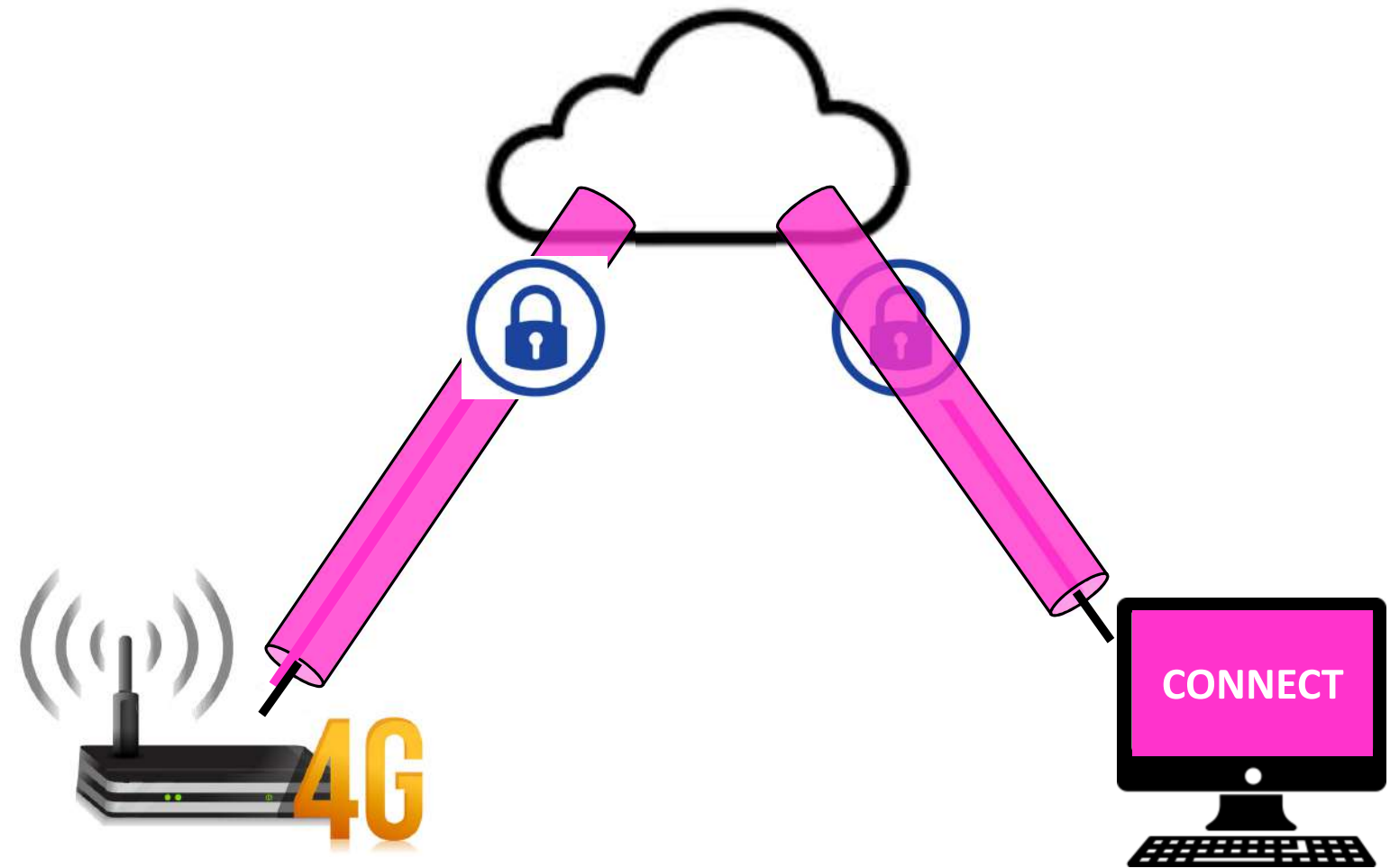
# Disadvantages of Client-Server Method

- Requires opening firewall
- Port forwarding in router
- VPN Client software
- Most IT departments **WILL NOT** allow you to open firewall, modify router settings, and install a VPN client on their network!



# Using a Cloud Service

- Remote requests connection to cloud server
- Remote is authorized
- User requests connection to cloud server
- User is authorized
- VPN tunnel established through cloud



# Advantages of Cloud-Based VPN

- Light-weight software running on base location computer
- Software runs as service in background
- Traverses firewall, handles remote IP address assignment
- No port forwarding or other changes required
- Able to have multiple base computers joining in a pool



# Cloud Service Providers

- Microsoft Azure
- Google Cloud
- Other smaller providers
- Some IoT (Internet of Things) router manufacturers provide their own



# Choose the Right Router

- Must be a smart router capable of connecting to cloud
- There are commercial grade routers designed for this, some specifically for IoT applications
- Router can be configured to always connect, or connect at only certain times or when certain events take place to reduce airtime charges
- Some routers allow user to write software which runs on the router, in order to add advanced buffering and connecting algorithms

# Conclusion

- Try to find a mobile service provider which can offer a Static Public IP address
- If can offer Dynamic Pubic IP address, use Dynamic DNS
- If cannot offer a Public IP address , there are two choices:
  1. Use a client-server VPN connection
    - Quite difficult to set up
    - Not recommended for using at client's site due to many IT changes
  2. Easiest method is to use Cloud-based VPN
    - Need to purchase router capable of Cloud-based VPN
    - Such router will be more costly, but worth the time saved

# *The End*

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to Instruments Over Mobile Network

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