Business White Paper

1:1 and Common Core Online Testing

Best Practices Guide for Network Infrastructures

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Audience

Executive summary

One-to-one initiatives provide a unique challenge for K-12 organizations. Organizations are struggling to provide the best education environment with ever decreasing budgets and increased regulation and compliance requirements. With careful planning and design, one-to-one initiatives can also provide the infrastructure for BYOD and standardized electronic testing requirements with little or no additional expenditure.

Failure to take into account all applications the infrastructure must support has required some school districts to replace over 50% of recently purchased end user devices. This reference architecture has been designed to guide K-12 technology departments in the design and deployment of one-to-one initiatives to avoid the most common and costly problems.

It is highly advisable that all executives review the 'Testing considerations' section as this will be vital to school districts implementing electronic testing. Electronic testing can easily be the most costly retrofit to an existing one-to-one environment, due to the strict testing device requirements of the testing applications.

It is recommended that executives read the guidelines written by the testing vendor of choice, as well as this document down to the symbol at a minimum.

IT director summary

This document is intended to help IT departments avoid common pitfalls that we have seen customers encounter over our many years of working with K-12 IT departments. This document is not, and no document, in our opinion, could ever be a complete list to guarantee a perfect deployment. We hope to help the community save time, money and headaches by consolidating our experience in the most concise form possible to be used as a guide.

Close attention should be paid to the software being purchased for standardized testing as these have the most stringent hardware requirements. Several K-12 IT departments have been faced with the prospect of repurchasing new client devices only months after a technology refresh, due to the hardware requirements that these new testing platforms require. This document is intended to bring this and other such topics to light during the design phase, rather than after the deployment phase.

High density wireless deployments bring about challenges for all IT organizations; however educational environments face additional unique challenges. The massive number of devices, frequency of mobility and increased security needs that all educational institutions must accommodate are some of the prime concerns. Planning for educational infrastructures must now take the number of devices and the applications being used on these devices into account, rather than the traditional wireless model of planning for the area to be serviced. When this is done with an eye to the future, the budgetary spend is spread over many years and user satisfaction is held at a high rate; however, too many organizations do not move to this model gradually and the forklift upgrade can be a substantial drain on an already stressed IT budget.

IT directors are highly encouraged to read this entire document. Material after the symbol is specifically included for our technical audience. We do encourage IT directors to also familiarize themselves with the testing vendor of choice for your state as changes will come from these vendors and this document may not include all updates.

***PARCC Assessment Administration Guidance Version 1.0-March 2013**

parcconline.org/sites/parcc/files/PARCC%20Assessment%20Administration%20Guidance_FINAL_0.pdf

Exam fundamentals

Appendix A: Estimated time on task by grade and session*

		Performance-based component						End-of-year component					
		ELA/literacy			Math		Total	ELA/literacy		Math		Total	Summative total
Grade		Literary analysis	Research	Narrative	Session 1	Session 2		Session 1	Session 2	Session 1	Session 2		
3	Estimated time on task (minutes)	50	60	40	50	50	250	60	60	55	55	230	8 hours

		Performance-based component						End-of-year component					
		ELA/literacy			Math		Total	ELA/literacy		Math		Total	Summative total
Grades		Literary analysis	Research	Narrative	Session 1	Session 2		Session 1	Session 2	Session 1	Session 2		
4-5	Estimated time on task (minutes)	80	80	50	50	50	310	70	70	55	55	250	9 hours, 20 minutes

		Performance-based component						End-of-year component					
		ELA/literacy			Math		Total	ELA/literacy		Math		Total	Summative total
Grades		Literary analysis	Research	Narrative	Session 1	Session 2		Session 1	Session 2	Session 1	Session 2		
6-8	Estimated time on task (minutes)	80	85	50	50	50	315	70	70	55	55	250	9 hours, 25 minutes

Note: Estimated time on task refers to an estimate of the amount of time the typical student will need to complete each session. While it is anticipated that most students will complete the test sessions within these estimated times, all participating students will have a set amount of additional time for each session to provide them with ample time to demonstrate their knowledge.

Electronic testing best practices

Standardized testing via computers does bring some unique challenges, however standard test taking best practices should still be adhered to. Some examples of testing best practices that should be continued with electronic testing are listed below:

- Twenty to thirty students per room
- Active monitoring during the exam
- Silence in the testing room

Some of the additional considerations with electronic testing are listed here:

Physical environment

- Students should place all cell phones in a location away from classrooms to prevent 3G/4G internet access during the test.
- Placement of visual barriers or a privacy screen guard for monitors should be in place.
- Power connections for every laptop/desktop/tablet must be provided or the batteries must be tested to ensure that they will hold a charge for the length of the exam + breaks + setup.
- Power cord safety needs to be designed for in the classroom.
- 504 accommodation students that are permitted additional test time to be placed away from common areas (cafeteria, gym, etc.) where other student cell phones may enable internet connectivity during the extended testing time.
- A minimum of two proctors should be placed in each testing room, one placed at the back of the room to watch screens and one placed at the front of the room to watch the test takers' faces and eyes.

For the most current Consortia technology requirements, please reference the technology sections of their web sites:

PARCC: parcconline.org

Smarter Balanced Assessment Consortium: www.smarterbalanced.org

Technology

- Guest wireless access should be disabled for the full day of the exam, if possible.
- Lock down of all network traffic other than the exam and critical systems (i.e.: phone) is recommended on the day of exam.
- We recommend that tests be taken on district owned devices for the following reasons:
  - Each student is guaranteed the same test taking experience.
  - The IT staff will be able to lock down district owned devices to prevent students from launching applications or sharing answers with other students during the test. This is not possible on student owned devices.
  - Wireless is a shared medium similar to radio which by its very nature is not a secure transportation method. If students are using wireless for test taking it is vital that the IT staff prevent students from using snooping software to watch what answers other students provide via the wireless network. Security can be enhanced by encrypting wireless traffic if a school feels the client side security is not adequate to prevent snooping of wireless traffic.

Technical requirement	Smarter balanced		PARCC	
	Minimum	**Recommended**	**Minimum**	**Recommended**
Hardware	Varies by operating system (XP needs Pent 233MHz, 128 MB RAM, 52 MB space available)	1 GHz processor, 1GB RAM, 80GB hard drive, 1 GB hard drive space available	512 MB RAM	1GB RAM
Screen size	9.5" minimum 1024x768 resolution			
Operating systems	Windows XP (SP3) Mac OS X 10.4.4 Linux(Ubuntu 9-10, Fedora 6) iOS 6, Android 4.0, Chromebook v19 Windows 8 (excluding Windows RT)	Windows 7 or 8 Mac OS X 10.7+ Linux (Ubunto 11.10, Fedora 16) iOS 6, Android 4.0, Chromebook v19 Windows 8 (excluding Windows RT)	Windows XP (SP3) Mac OS X 10.5 Linux(Ubuntu 9-10, Fedora 6) iOS 6, Android 4.0, Chromebook v19 Windows 8 (Windows RT has not been evaluated)	Windows 7 or 8 Mac OS X 10.7+ Linux (Ubunto 11.10, Fedora 16) Windows 8 (Windows RT has not been evaluated)
Headphones/ microphones	Headphones are available to students for use during the English language arts test and for students who require text-to-speech features on the mathematics test. USB headphones are recommended, as they are typically plug-and-play devices. However, standard headphones connected via standard TRS (headphone jack) connections will suffice.		Headphones/earphones are required for all students for all PARCC assessments. Some student accommodations may also require headphones/ earphones e.g., text to speech). Microphones are required for all students taking the Speaking and Listening Assessment.	
Physical keyboards	Mechanical keyboards must be available unless students use alternative input devices as part of their classroom instruction.		PARCC assessments will require external keyboards for test takers using tablets.	
Network bandwidth	Must connect to the Internet with approximately 10-20 Kbps available per student to be tested simultaneously.		To be determined by October 2013	Internal connection of 1,000 Kbps per student internally and 100 Kbps per student externally to the Internet.
Form factors	Desktop, laptops, netbook, virtual desktops and thin client, tablets (iPad, Windows, and Android) and hybrid laptop/tablets		Desktop, laptops, netbook(s Windows, Mac, Chrome, Linux), thin client, and tablets (iPad, Windows, and Android)	
Future advancements	According to their June 2012 report, by 2016-2017, students will need access to a tablet (or other device) that employs a stylus for user input as up to 25% of math assessments will comprise items/ tasks requiring student produced illustrations or calculations.		Computers meeting the recommended specifications can be expected to satisfy PARCC guidelines through the 2018-2019 school year.	
Security	The device must have the administrative tools and capabilities to temporarily disable features, functionalities, and applications that could present a security risk during test administration (as per February 2013). In their June 2012 report these include, but are not limited to, Web browser access, cameras (still and video), screen capture (live and recorded), email. text messaging, Bluetooth connections, application switching, and printing.		Eligible devices of any type or operating system must have the administrative tools and capabilities to "lock down" the device to temporarily disable features, functionalities, and applications that could present a security risk during test administration. These include, but are not limited to, Web browser access, cameras (still and video), screen capture (live and recorded), email. text messaging, Bluetooth connections, application switching, and printing.	

– Personal devices can be temporarily 'locked down' to prevent access to non-test applications, Bluetooth connections, Internet access, social media tools, etc., but many personal systems become 'unlocked' after a reboot. Students understand this and are very likely to reboot a 'locked down' device in less than 2 minutes, which could place all test results for the school under suspicion.

Testing requirements

Each testing environment has its own unique client requirements. Here is a chart showing two very common standardized testing consortium requirements. You should evaluate your test software client recommendations to ensure that hardware purchases will support such testing software needs. Failure to closely review and analyze these software requirements can easily cause a K-12 to have to repurchase new client devices for all students.

The impacts of these requirements are listed below:

- Requiring both physical keyboards and the temporary disabling of Bluetooth eliminates the eligibility of most tablet computers since this is how most tablets communicate with external keyboards today. Test all client devices prior to purchasing to ensure compliance.
- Requiring the temporary disabling of features and functions on a device requires that the device be owned by the district, rather than the student in most cases. Please contact legal representation to discuss the ability of the district to enforce a locking of student owned devices.
- The requirement for headphones and the future stylus user input devices adds purchasing, maintenance, hygiene and storage complexity.
- 9.5" minimum and 1024x768 resolution disqualifies many small and medium sized laptops which are popular with K-12 for student use.
  - This can be worked around by providing external monitors on the day of the exam; however this does add the complexity of additional cables (video and power) and additional power draw in each room on the day of the exam.
  - If this choice is selected it is advisable to train teachers to connect monitor cables to prevent hardware damage to the pins.
  - Spare monitors should be provided on the day of the exam to quickly replace any malfunctioning or damaged monitors.
- Internal and Internet bandwidth requirements on a per student basis will require monitoring tools able to demonstrate that these levels have been met and logging should be kept for the day of the exam in the event of a challenge to the validity of the testing environment.

Common electronic test-taking pitfalls to avoid

Many different ideas have been tried with testing that seem great at the design phase, but which fail to be viable in implementation. Here are a few of those ideas and why they have failed to help schools avoid similar pitfall:

1. Testing in a communal area such as a cafeteria, gymnasium or auditorium.
    a. Wireless coverage for several hundred students in a small location requires a complex number of technical factors to be designed for PRIOR to implementation.
        i. Access Point power must be reduced so that each client device gets service. Dense user environments no longer need a space coverage model, but rather a device coverage model. Most AP radios are optimized to service ~15 devices, which in a cafeteria or auditorium would require you to have a wireless cell size reduced to prevent overlap between conflicting cells (see diagram on page 11 for an example and review the last page of this document for cell overlap data).
        ii. Many additional AP's will need to be installed in this area for the test day(s). See point i for small cell size and extrapolate 1 AP radio per 15 devices and you will be able to roughly calculate the increased number of AP's for this deployment.
        iii. AP's are not needed in this density for the rest of the year, so they can either be removed and installed elsewhere, or left in place and not utilized for the remainder of the year. The complexity of this deployment is so high and its impact on other surrounding wireless is so high that it becomes unrealistic for most organizations to remove this high density wireless deployment when not in use.
        iv. Humans are roughly 70% liquid and wireless signals do not transmit through liquid well. When a large number of humans are in a small area this causes unique wireless problems that cannot be easily simulated. Few schools are able to place hundreds of students into an auditorium with laptops for several hours in order to optimize the wireless and thus this has had very limited success in large scale deployments.
        v. Cart deployment of APs while very efficient in classroom settings as a temporary wireless solution, does not scale easily for large areas due to cell and channel overlap.
    b. When you have several hundred power cables running to each student's device in a large area you run into the following issues below. Newer devices that can run for 4+ hours on battery should be charged overnight and used whenever possible to reduce these issues.
        i. The room may not have enough power to service that many devices.
        ii. Hundreds of power cables on the floor create an OSHA safety issue.
        iii. Close proximity of a large number of students allows for eyes to wander more easily between many different screens.
        iv. Laptops generate heat if used on a lap and should be used on lap desks for a multi-hour exam. We are not aware of any K-12 who has several hundred lap desks for this purpose. Some schools do bring desks into gymnasiums to provide a place for laptops to sit comfortably.
    c. Physical discomfort and distraction of students.
        i. With a total of 8 to almost 10 hours of testing being required for various grades, even when split up, this makes for serious neck strain if students are looking down at laptop screens on lap desks. Most schools choose to bring desks into the area for laptops to set on and prevent this neck strain.
        ii. Students passing each other in auditorium seats to use the rest room, etc. will distract other students they move by while taking the exams.
        iii. Students who complete exams early are more likely to become a distraction to surrounding students if being tested in a high density environment.
2. Allowing students to use personal devices for testing.
    a. Personal devices cannot be adequately locked down in most circumstances. Students and/or parents install software on personal devices which can do the following:
        i. Bypass network security and allow students to browse the internet or launch non-test applications, while taking a test.

ii. Watch the screen of other student's devices, while taking a test by using desktop sharing applications.

iii. Capture test answers as they are sent over the wireless network by using network data capture applications.

iv. Battery life is hard to determine when each student has a personal device. These devices should be connected to power outlets and power cords should be brought in the day BEFORE the exam to ensure the proper power cord is being used for each unique device.

b. Reduced testing experience for all users.

i. The speed of a wireless network access can be drastically affected by older devices. Wireless networks work as a hub and can only go as fast as the slowest device on the network.

Example: if a single student brings in an older laptop that runs wireless at 802.11b speeds then it will slow down all newer devices in the wireless cell that would have been running at much faster 802.11n speeds.

ii. Viruses on personal systems can flood the wired or wireless networks with unnecessary traffic which can cause areas of the campus to encounter slow test-taking.

iii. Instructors must accommodate for a plethora of unique devices that may have different power connectors, display adapters, etc. which are required on the day of the exam and the student may or may not have.

Recommendations for high density wireless

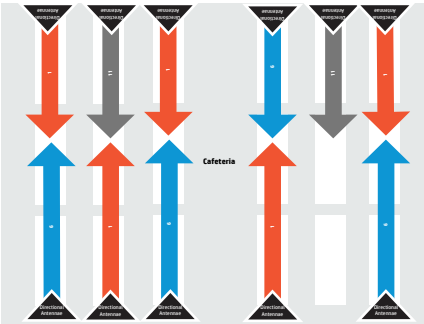
1. Use this document.
   a. We have outlined common mistakes to help you avoid them.
   b. The last page of this document has technical information that all wireless engineers must understand for successful wireless deployments.
   c. If you do not have wireless expertise on staff, then it is best to have a specialist provide the installation on your behalf. This is less expensive and provides better results than the 'do it yourself' approach. We have outlined the services HP provides in this document should you need them.
2. Plan to setup the environment 60 days prior to the test.
   a. You will need to create 'heat maps' of the wireless coverage area to see where you need to avoid placing students, such as behind pillars/beams/water pipes, etc.
   b. You may need to place APs in the ceiling, mount them to walls, or have them on carts. Sixty days gives ample time for facilities to assist in the safe installation of these devices.
3. Run a test of the wireless performance 30 days prior to testing.
   a. This can be done by having a general assembly of the student body in the location that the test will be done in and then having all students access a website to place several live 'votes' that are then shown on a projected view.
      i. Examples of questions:
         1. What should we have for lunch on Friday?
            a. Pizza
            b. Spaghetti
            c. Hamburgers
         2. Do you like real time voting?
            a. Yes
            b. No
         3. Did you have any slow response when voting?
            a. Yes
            b. No
         4. If you or your neighbors are having slow connections, please tell us the seat and row number that is having problems so that we can fix it.
   b. This provides you with a real test of the wireless performance on a lightweight application with the number of students in the area you plan to test in. You can use answers to example question 4 to locate dead spots or slow areas that you can either fix while the students are in the location or you can simply not place students at those locations on the day of the exam.
   c. If you want to test throughput with all users, you can ask students to hit 'play' on an Internet video at different times, essentially setting up a 'round' of the video. Something like 'row, row, row your boat' works well for this and will allow you to see and hear where network performance is lagging as the network is stressed by more devices being added per section.
      i. The Internet link needs to be monitored when this test is being run to ensure that Internet saturation is not the cause for videos playing at slow speeds.
      ii. The network uplinks should also be monitored during the test to ensure they are not the bottleneck for performance.
      iii. The wireless APs should be monitored when this test is being run.
      iv. This is a fun and interactive way for students and administrators to understand the capabilities of the high density wireless environment.

4. Design AP coverage model.

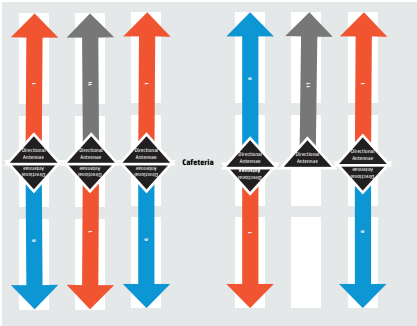
a. The left side in each of the following diagrams show full coverage and the right side shows a lack of full coverage due to channel mapping issues. In some environments, it will be beneficial to not service an area due to a pillar or other obstruction that would make servicing that location cost prohibitive. These should be clearly marked on the days of testing.

i. Linear works well for rows with a clear line of sight, such as cafeterias without pillars.

1. This diagram shows linear coverage with directional antennae mounted to the wall or placed on carts at the end of the row of tables.

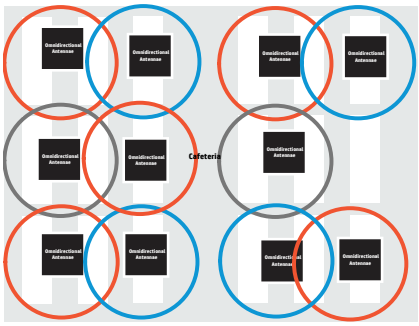


2. This shows the same layout, but with directional antennae's mounted in the ceiling. You can see that you now only need ½ the number of devices, but that they need to have dual antennae/radio functionality.

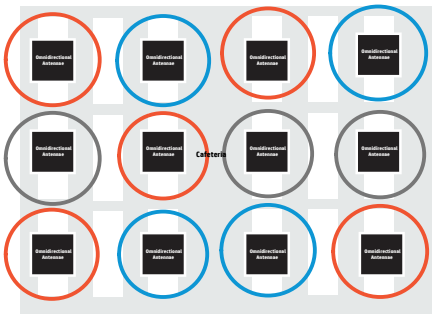


ii. Cell coverage works well for pockets of users.

1. This model services each table, however the possibility of overlapping channels is high.



2. By reducing the cell size slightly and adding an additional AP you can prevent channel overlap.



b. Keep these design principles in mind when designing a high density wireless solution.

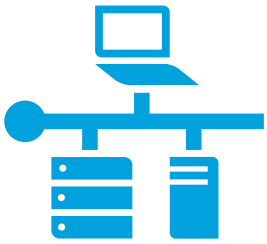
i. 90 degree angles are preferred if the signal needs to pass through a wall (sheetrock is preferred for this) 45 degree and other non 'square' angles cause signal attenuation.

ii. If a cell is too large then all clients in that cell will have problems.

iii. If a client is behind an obstruction they will have problems that can affect all users in that cell.

iv. Adding power to a radio will raise the 'noise floor' and usually decreases user service.

v. When adding an AP you should not overlap with other radios on the same channel. Auto channel APs do help with this; however you need to be aware of how adding a single AP can cause a chain reaction of changes throughout your wireless network.



Infrastructure design best practices

Wireless design best practices

When looking at wireless network design to implement for K-12 environments to meet the needs of BYOD, one-to-one and standardized testing, the natural tendency is to only think of the wireless network. However in order for the wireless network to perform to expectation, other portions of the network need to be addressed.

Wired network core design

With the criticality of the wireless network growing with initiatives like BYOD and standardized testing, insuring that the wired network is operational and ready to accommodate all the users these initiatives will bring is critical.

For a network to offer redundancy and performance, several things need consideration in the core network such as switch virtualization for redundancy, ISSU (In Service Software Updates) for network uptime, and 10GB links to the IDF (Independent Distribution Framework) closet to accommodate the added traffic loads.

Switch virtualization like HP's IRF (Intelligent Resilient Framework) provides a method to allow two physical core switches to operate as one virtual switch allowing for redundant connection to critical resources like servers, while utilizing industry standard protocols such as LACP (Link Aggregation Control Protocol). Switch virtualization also helps to reduce the complexity of the network by eliminating the need for protocols such as VRRP (Virtual Router Redundancy Protocol) and Spanning Tree Protocol (STP) in the data center. Since with switch virtualization the two cores operate as one and share information like route tables, they provide layer two and layer three redundancy, while reducing network complexity.

ISSU provides the ability to do core switch software updates without the need to schedule downtime on the network. With many K-12 districts moving forward with BYOD and testing initiatives, it is becoming more difficult to schedule network downtime. With ISSU, network core switches can be patched and software problems fixed without the need to schedule network downtime.

As K-12 districts look to move more of their users from wired to wireless devices, a close analysis needs to be done on the bandwidth that is provided to the access layer devices. Not only are the number of devices on the network increasing, but also the amount of bandwidth an AP can provide is growing. Today, most customers are installing 802.11n APs with either 2 or 3 spatial streams. The more streams an AP can provide, the higher the amount of bandwidth available to users. For example, the HP 430 AP is a dual radio AP; one radio is 2.5 MHz (54 Mbps) and the second radio is 5 GHz (300Mbps). The HP 460 AP will provide up to 450 Mbps on radio two. So with the amount of bandwidth increasing per AP, having ample bandwidth to the access layer is a must. Many customers today are only connecting their wired devices to the network at 100 Mbps connection and when these connections are moved to APs, the 100 Mbps connection will throttle the amount of traffic an AP can provide. So when installing a new wireless network, 1 Gbps connection to the APs is required.

Since the connection speeds to the APs is increasing, a close look needs to be made of the connections between the IDF and MDF closets. The best practice for wireless networks that are installing 802.11n APs is to upgrade the backbone of the network to 10GB. This step will not only help meet the requirements of today's wireless network, but will also provide a good building block for the 802.11ac AP, providing over 1 Gbps of bandwidth, that are starting to ship this year.

The last portion of the wired network that needs to be examined is how all the APs are going to be deployed and powered. The best practice when it comes to powering the APs is to install Ethernet switches that support PoE (Power Over Ethernet). These are devices that can provide power to the APs over the data cables that will be connected to each AP.

When looking at PoE enabled Ethernet switches, two questions need to be considered:

1. Does the switch have a big enough PoE budget to power all the APs that will be connected to this switch?
2. Do I need redundancy for the PoE in case of a component failure in the switch?

For example, an HP 2530 Ethernet switch has a PoE budget of 382 watts. If the APs draw 12.5 watts (HP 430), 15 APs can be powered on a 24 port switch, whereas the HP 3800 switch can provide a PoE budget of 720 watts and 24 plus APs can be powered. Each customer environment is unique and you can quickly calculate your power needs by using the formulas found on this page.

Special consideration should be taken if the K-12 facility is considering deploying the new 802.11ac APs because these may require more than 12.5 watts. This is because of their higher performance and multiple channels. Dual channel 802.11ac does provide significant increase in user capacity and we see it as a natural upgrade for the K-12 sector; however, single channel 802.11ac will rarely provide additional performance for K-12 customers since it does not address the core problem with single channel communication. K-12 organizations should carefully read 802.11ac device claims as the difference between single and dual channel can be a costly mistake to make.

Prior to 802.11ac, all HP APs, even those providing 3:3 MIMO on 802.11n were kept in the PoE power budget due to our strict internal power efficiency standards. This allowed HP wireless customers to avoid the costly upgrade to PoE+ on the wired infrastructure which extended the life of many PoE switches throughout K-12 environments. With 802.11ac, this will no longer be a guarantee, and the physical infrastructure should be ready for some devices that need PoE+ in the future.

Since so many of the devices in the K-12 environment are moving from wired to wireless, the best practice is to consider providing redundancy for PoE in key areas of the building. Key areas could be offices, classrooms and testing labs. If redundancy is required, selecting an Ethernet switch that provides for redundant power is critical. For example, the HP 3800 Ethernet switch has the ability to have a second power supply installed, so that in the event of primary power supply failure of the switch, the second supply will take over powering of the APs and prevent an interruption in data traffic.

You cannot extract more power from a closet than the power going into the closet. This sounds like an obvious statement; however, this is a pitfall that many K-12 engineers have fallen into. If a device promises to provide PoE or PoE+ on every port, but you cannot power that device, then you are paying dearly for a function you cannot use without adding the expense of running additional power circuits to that device. Here are the most common calculations to keep in mind:

Amps x Volts = Watts

PoE = 15.4 Watts

PoE+ = 30 Watts

Example: 20 Amp circuit X 110 Volts = 2,200 Watts

If divided by 15.4 Watts = 142.86 ports at PoE power

If divided by 30 Watts = 73.3 ports at PoE+ power

This is a THEORETICAL maximum since we have not taken the following into account:

1. The power it takes to run the switch.
2. The power it takes to run other devices in the IDF closet.
   a. Since this number is drastically different for each customer, we cannot give guidelines here. Please calculate ALL devices using power in your IDF closet and subtract that from your available power.
3. Electrical circuits normally should not be loaded at higher than 80% utilization. This prevents power overloads that may occur if all devices in the IDF closet boot at the same time (such as after a power outage).

Your calculations will look similar to the following and should be calculated for every PoE source area:

Example: 20 Amp circuit X 110 Volts = 2,200 Watts

2,200 Watts * 0.8 (80% of circuit) = 1,760 Watts available

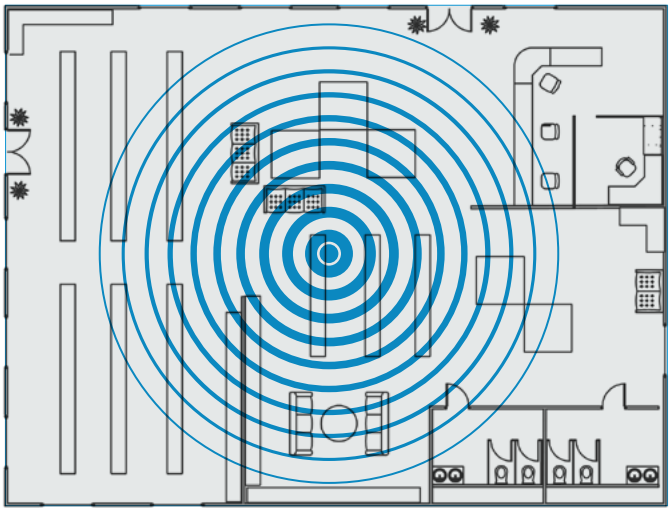
1,760 Watts – 909 Watts (to power HP 3800-24G-PoE+-2XG 2x power supply switch)

What you have now:

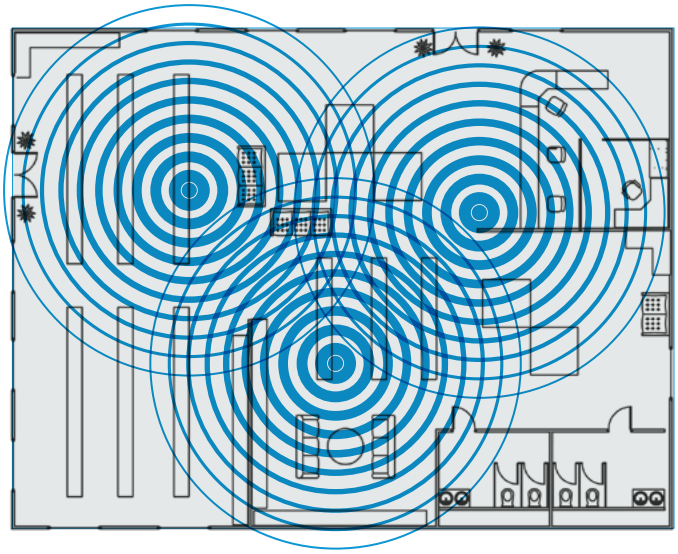
- An HP 3800 switch with 24 ports of full 30 Watt power (720 Watts total)
- 851 Watts available in closet for other devices

Wireless network design best practice

With the new pressures on K-12 of standardized testing added to the existing pressures of BYOD and the ever increasing number of devices, districts are being forced to change their wireless deployment models. The previous model for AP deployment was to cover an area, but the new deployment model must focus on providing enough bandwidth for the number of devices in the area.



As shown in the picture above, before these new pressures, one AP was deployed to cover an area so that if someone had a laptop they could get connectivity in a meeting without the need for a data cable. This was good for a few wireless users, but this model does not scale for a high density deployment where many users will need reliable network access in the same area.



Today, as shown in the picture above, the same area may now be covered by three APs not only providing coverage, but also additional cells of bandwidth so the wireless network has the capacity to accommodate the number of devices the environment needs to support. With wireless networks moving to these types of deployments, using a controller based wireless system is a must. A controller based wireless solution provides a central brain for configuration, monitoring and configuration control which simplifies deployment and maintenance, while increasing security.

Wireless controller – best practices

The wireless controller not only provides for ease of management, but also serves a key function in controlling and optimizing the function of the APs, and with the increase in the number of APs being deployed today, AP optimization is critical for users to have a good wireless experience.

For example, the HP Wireless Unified Controllers provide several features that help with the optimization of the wireless. Two features in particular are RRM (Radio Resource Management) and Band Navigation/Band steering.

With RRM, the controller is able to set both the channel and power levels of the APs to optimal levels to minimize interference, while providing an optimal roaming experience for the users. To meet the requirements of the new online testing standards, K-12 districts are going to deploy the APs in a dense deployment model as dictated by a site survey, and when APs are deployed in this method, the cell size of the APs has to be reduced to minimize interference. In other words, the power of the APs has to be reduced so the density requirements to support the number of devices can be met. If the wireless controllers cannot properly set the channel and power of all APs, then users will not roam to the closest APs and as a result, will not have the bandwidth needed to support the online testing applications.

A best practice when building a wireless environment to support initiatives like BYOD and standardized testing is to deploy dual radio APs such as the HP 430 and 460 models. Dual radio APs have one radio to support the 2.4 GHz devices and a second radio to support the 5 GHz devices. Devices that only support 2.4 GHz will only connect to radio one, however devices that support 5 GHz are backwards compatible with the 2.4 GHz radios so they can connect to either radio. A best practice feature to enable when deploying dual radio APs is Band Steering/Band Navigation. This feature encourages clients capable of using the 5 GHz radio to use it instead of staying on the 2.5 GHz radio. Enabling this feature will benefit all clients since it will help move clients off the slower 2.4 GHz radio, thus improving their performance and providing more bandwidth to the faster 5 GHz clients.

As the demands on the wired and wireless network continue to change, the way the wireless user traffic needs to change as well. In the past, wireless networks only needed to deal with traffic from district owned assets, so the traffic was trusted and could be placed directly on the wired network from the APs. Today, K-12 districts must deal with several different types of traffic, from guests at board meetings to teachers and students bringing in their own devices and wanting access to district resources on the network. Therefore, controllers need to be a lot more flexible. For this reason, when planning a wireless network, the wireless controller needs to be able to support a distributed architecture for trusted traffic and centralized traffic flows for untrusted traffic because each of these traffic types require a different level of security. If the controller deployed for a wireless network only supports a central traffic model, all traffic flows through the controller. As AP technology advances and delivers more bandwidth to the users (for example 802.11ac) central traffic model controllers will quickly become a hindrance to the flow of traffic because their throughput cannot support the level of traffic. Controllers that support a distributed traffic module such as the HP Unified Wireless Controllers will be able to handle the advances in AP technology since they do not force all traffic to transit the controller.

Access point best practices

There are many different types of APs available on the market today offering different speeds and antenna orientation so several factors need to be considered. Many times budgets will determine which type of AP gets deployed and in today's market would be a 3X3:3 AP much like the HP 460. This type of AP offers 3 transmitting antennas and 3 receiving antennas with 3 spatial streams, which is top of the line on the market today. However, if the user community devices being serviced by the wireless network do not have 3x3:3, then minimal benefit will be observed immediately. The APs will have a longer technology life in such environments. For K-12s with non 3x3:3 capable client devices, a 3x3:2 AP like the HP 430 will meet the requirements of the current user community. This brings us to the last factor to consider in the decision of purchasing APs - the client device refresh cycle. If the clients will be refreshed in the next one to two years, then purchasing the higher performing 3x3:3 AP will be beneficial for a longer life span in your environment.

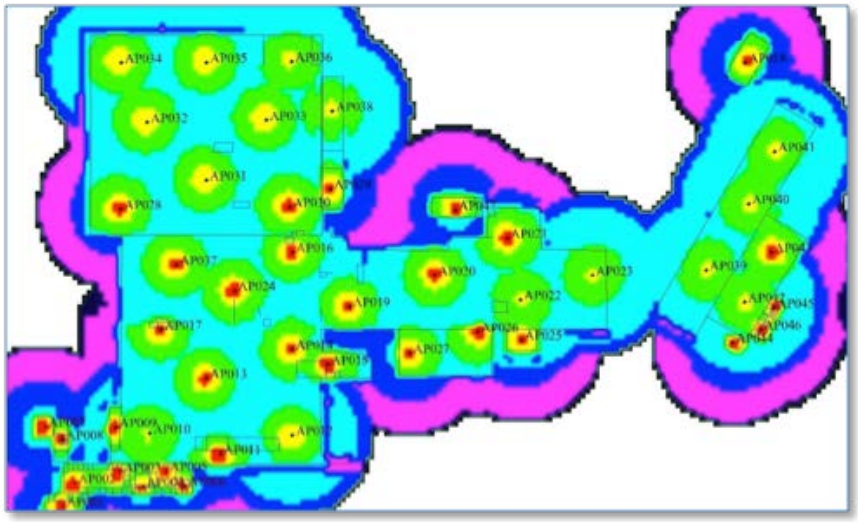
Implementation guidelines and services

If no wireless environment exists
If an AutoCad-generated floor plan is available, order a remote predictive wireless site survey with AutoCad (HL016A1). This will use AutoCad's layers to determine wall types, thicknesses, etc. Additional information including the number and types of wireless devices such as laptops to be used will also be needed. The result will be a document showing the optimum number of APs to implement and optimum placement of each AP in the areas designated for wireless access.

If an AutoCad-generated floor plan is not available, but a softcopy floor plan is available, order a remote predictive wireless survey without AutoCad (HL017A1). Some manual setup will need to be done by our consultants to figure wall types, thicknesses, scaling, etc., but the result would be the same, a wireless capacity planning document showing the optimum number of APs to implement and optimum placement of each AP in the areas designated for wireless access.

If no software floor plan is available, order an onsite wireless survey. The consultant will arrive onsite with equipment to measure signal strength and interference in an area designated for the wireless environment and detect if any rogue APs are present. As with the remote predictive wireless survey, the result will be a document showing the optimum number of APs to implement and optimum placement of each AP in the areas designated for wireless access.

The figure below is an example of a wireless survey heat map illustrating AP number and placement using 802.11n in the 5GHz wireless range.



For best results
If possible, and if the wireless products currently in use support it, use 802.11n in the 5GHz range for increased throughput and separation from wireless interference common in the 2.4GHz range (devices such as microwaves, car alarms, fluorescent lights, etc.)

Shop areas such as auto shop, metal shop, wood shop, etc. may generate interference to diminish or even prevent wireless access due to the number and type of power tools in use during class. Once the wireless network is in place, use a wireless laptop to check and verify wireless connectivity in these areas.

Wireless security
Implement a WPA2/AES encryption scheme for communications between the wireless end-stations and APs so the wireless stream cannot be accessed by others, if possible. Some clients only support WPA and these will require the district to either upgrade the client or downgrade the security encryption scheme used to accommodate these devices.

Establish a separate, isolated, non-routable VLAN as the egress point for wireless end-users that only allows access to the servers and testing environment being used.

Set up separate end-user accounts, possibly just during testing, and implement 802.1x authentication for access control.

Issues with current wireless setup

If there are issues with wireless connections dropping, interference, etc. in an area where the wireless environment exists, it is recommended to order an onsite wireless survey. The onsite survey will check interference levels, locate areas where the signal is weak and prone to drop off, and check for the existence of rogue APs in the same wireless environment. The onsite wireless survey result will be a wireless capacity planning document showing interference levels, areas of weak signal strength, rogue APs, as well as showing the optimum number of APs to implement and optimum placement of each AP in the areas designated for wireless access.

Wireless lifecycle consulting services from HP

As shown in the table below, HP provides a full lifecycle of consulting services to implement a wireless environment per the requirements, goals, and specifications regarding a secure and effective testing environment. These services are based on a standard HP integrated approach for survey, design, deployment and verification. We bring these up since many districts do not have the staff with the experience needed to perform site surveys.

Service	Description
WLAN Site Survey	Determines the placement of the APs to provide the necessary coverage and capacity of the wireless system to meet the requirements based on physical site characteristics, applications utilized, and end-point types. WLAN Site Surveys may be remote predictive surveys, onsite surveys, or a combination of both. Onsite Surveys may include a cabling survey.
WLAN Site Readiness Assessment	Assessment and Analysis of the LAN switch infrastructure to determine remediation actions necessary to support new WLAN design for technologies such as 802.11n and/or 802.11ac. This service may include a cabling survey.
WLAN Design & Security Consulting	Consulting and assessment of the existing security infrastructure to design and configure the WLAN security and/or guest portal access and authentication needed to allow safe WLAN system and application access. Determine and document the final WLAN configuration, operation parameters, and make recommendations for routing, switching, and segmentation based on the output from the Surveys, Assessments, and Client business requirements.
WLAN Deployment Planning	HP prepares the schedules, plans, and acceptance testing criteria based on the WLAN Design for the actual Implementation and migration to timely deploy the new solution with minimal interruption to the current operations.
WLAN Deployment	Install the WLAN devices, apply the configuration to WLAN devices, and turn up and perform acceptance testing of the WLAN solution including WLAN controller(s) implementation, AP registration and configuration, LAN Switch configuration changes, and finalize the as-built documentation.
WLAN Post-Deployment Optimization	Conduct an actual measurement of the deployed WLAN coverage and AP density (capacity) to show the as-built WLAN capabilities and provide a WLAN baseline for future reference.
IMC WLAN Network Management	Implement HP Intelligent Management Center (IMC) management platform and the Wireless Services Manager module to provide visibility into the WLAN network and perform configuration functions.
IMC Advanced End-User and/or End-Device	Implement HP IMC modules such as User Access Manager (UAM), Endpoint Admission Defense (EAD), User Behavior Auditor (UBA) and/or Network Traffic Analyzer (NTA) to control and monitor user and devices access to the network. Only appropriate users and devices obtain appropriate access rights to the network and users compliance with company policy is verified after obtaining access rights to the network.

The school or educational/testing facility can take advantage of any or all of these services as their needs and requirements dictate.

Wired implementation – best practices

If no wired network exists
The Network Strategy and Planning Service is recommended for those schools and/or testing facilities that have no network in place. Under this service, the HP Technology Consultant will develop high-level roadmaps, network blueprints, network topologies, and implementation strategies to implement a high availability, high throughput network necessary for the testing environment.

For best results
Resiliency is important for wired networks. Due to mandatory specific dates and times, the network design must be able to quickly mitigate issues resulting from single points of failure. An example of a single point of failure would be a single Internet router.

Make sure all end-user devices being used for testing has either the correct IP address or can acquire the correct address from a DHCP server.

Make sure adequate power is available for all end-user equipment (PC's, laptops, etc.) as well as for the network.

Wired security

The following list is provided as options to consider when putting together a dedicated network for testing. It is important to focus on isolation and security when establishing such a network:

- Implement a separate network in the testing area to only provide connectivity to the required servers on the testing website.
- If implementing a separate network is not feasible, establish a separate, isolated, non-routable VLAN that only allows access to the servers and testing environment being used.
- Implement Access Control Lists to restrict network traffic to only the servers and testing environment being used.
- As with wireless implementation, setup separate end-user accounts, possibly just during testing, and implement 802.1x authentication for access control.

Issues with current wired network setup
If there are issues with apparent network slowdowns, errors, etc. in the network, to the point that the network cannot be relied upon to provide testing services, a Network Assessment Service, Network Architecture and Design Service, and/or Network Optimization Service may be required. These services focus on the current setup, measure throughput and errors during a defined duration, determine a gap analysis, and provide recommendations and planning to remediate these issues and bring the network up to a standards-based, high throughput, and resilient architecture.

Wired lifecycle consulting services from HP
As shown in the table below, HP provides a full lifecycle of consulting services to implement a wired network environment per the requirements, goals, and specifications regarding a secure and effective testing environment. As with HP's wireless services, these services are based on a standard HP integrated approach for survey, design, deployment and verification.

Service	Description
Network Strategy & Planning Devices	These services define high-level strategies and roadmaps, business case developments, high-level solution design and blue prints, and interoperability and transition strategies.
Network Assessment Services	Typically, the need for assessment and analysis is driven by initiatives such as consolidation, centralization, and virtualization of network environments– and when you are deploying new applications or technologies. HP network consultants employ a structured methodology to accomplish these objectives by collecting and analyzing detailed data of your networks characteristics. These services include: assessment of end-to-end environment readiness, gap analysis and program planning, recommendations and roadmap.
Network Architecture & Design Services	These services offer detailed network architecture and design for campus, wireless, and data center local area network (LANs), leveraging HP's reference architectures and methodology. Included are high-availability options, established design principles, the use of network protocols in conjunction with various network topologies, and other considerations. The goal is to provide a scalable, resilient network architecture within a best-practices framework.
Network Integration & Deployment Services	These services coordinate the end-to-end integration and deployment of network implementation. HP can bring the network online, add new connections to an existing network, or guide the transition to the new network environment, while scaling the solution to fit the requirements.
Network Optimization Services	These services enable critical applications to meet performance service-level agreements (SLAs) by proactively detecting problems via continuous monitoring during production.

The school or educational/testing facility can take advantage of any or all of these services as their needs and requirements dictate.

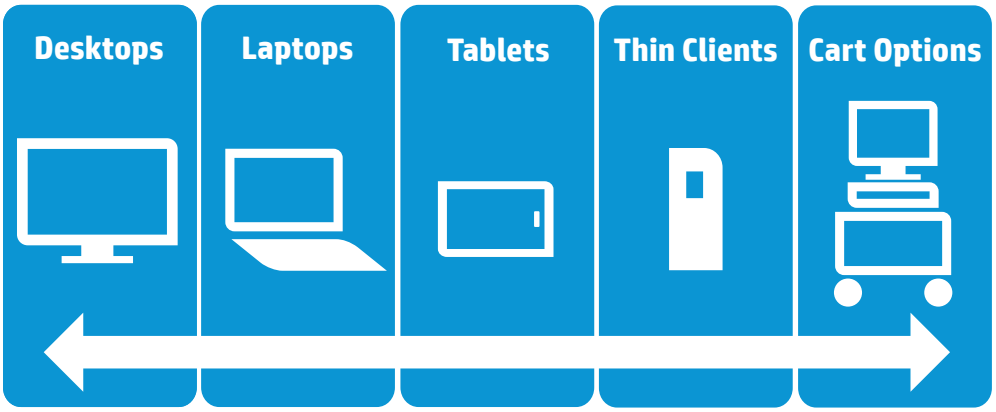
Extension – devices suitable for Common Core

While the focus of this document is on the network, schools and districts must certainly understand that a holistic approach to addressing One-to-One and Common Core is going to include both the student devices and the network to which they connect. Presented below are some key considerations regarding those requirements, along with a summary of considerations and compliant HP devices in each form factor. Additionally, Appendix C includes a detailed review of the Thin Client options that satisfy Common Core requirements, particularly for schools that have deployed or are considering VDI approaches.

Requirements
The technical requirements for devices that the PARCC and Smarter Balanced consortia have provided are clearly outlined, and leave some latitude to schools for choices about form factor and operating system. Several important points are worth special attention:

1. Mechanical keyboards are required for tablet devices. Schools should also pay close attention to requirements excluding Bluetooth as an option for keyboard connections.
2. Smarter Balanced issued a report in June 2012, stating that by 2016-17 they will require stylus/pen inputs for 25% of the math assessment.
3. Devices must be able to be fully locked down during testing. For each form factor and operating system, schools should closely consider this requirement when selecting an approach to devices. For example, many states have determined that BYOD units will not be acceptable.
4. A minimum student to computer ratio of 7:1 should be anticipated.
5. Schools with an install base running Windows XP should pay close attention to the end of life for support, as this will drive the need for device refreshes as well.

Form factors
Schools should recognize and embrace the fact that the device requirements for Common Core do allow for a variety of form factors and operating systems. HP's philosophy is that the technology choice should follow the educational need, whereas other may try to convince you to adapt teaching and learning to their device. HP offers desktops, laptops, tablets and carts. But we also offer a wide array of thin client computing, which not only meets the requirements, but offers ease of management, low-cost field support and lower total cost of ownership. These attributes have actually made it the choice for computing platforms for many school systems across the country.



Desktop/Traditional Computer Lab Testing Options allow schools to leverage existing labs & infrastructure with simple refresh:

- HP ProDesk and ProOne options for CPU and All-in-One options
- ProDesk available in multiple form factors from towers to small form factors
- All-in-One options available with and without touch
- ProDisplays allow for 18-25" screen size options, adapting to users and actual desk space

Mobile Laptop Computing Test Options offer varying sizes, operating systems and processing choices:

- Laptop choices ranging from 11.6" to 17"
- All day battery life choices with 8+ hours or more
- Popular choice has been HP ProBook series with Windows 8
- Chromebook options available

1-1 Tablet Style Testing Options meet all requirements and make tablets an easy choice:

- Windows 8 tablets provide full PC computing experience
- HP ElitePad with Productivity Jacket, Revolve and Envy x2 all offer direct connect keyboard
- No Bluetooth means cleaner communication, longer battery life and no charge for additional accessories
- Pen options for Revolve and ElitePad; Stylus option for Envy x2 to comply with future testing needs

Turnkey' Mobile Testing Cart Solutions offer a choice of laptops or tablets in 20 and 30 unit carts:

- Compatible with a large variety of tablets and notebooks, up to 15.6 inch screen size
- Smart Charging Technology: Load-sensing technology directs charging power when and where it's needed most
- Retractable Front Doors + Removable Shelves
- Service Compartments:
  - Two locking rear panels allow access to the AC adapters and Ethernet cabling
  - The top locking panel of the cart is removable for access to IT equipment (i.e. WAP/router, Ethernet switch(es) and controller box)

Thin Client Computing Test Options offers easier management, and lower total cost of ownership:

- Manage all computing from the data center
- All students still have their own personal cloud desktop
- Easier repairs in schools and classrooms
- Meets the technical requirements of the two main Common Core testing consortia

As a reference for schools considering thin clients for 1:1, or VDI for their environment overall, we have provided in Appendix C a detailed review of the technical and practical considerations of various thin clients.

Appendix A - definitions

AP – Access Point : An Access Point provides wireless network connectivity to devices.

Cluster : A group of devices working as one. The devices share the same configuration and service all devices the same.

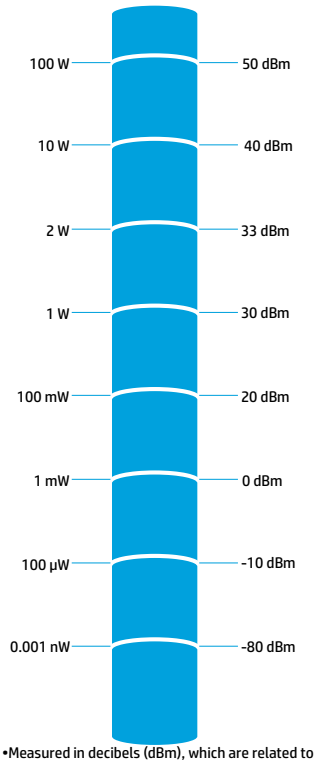
Controller : A controller is a centralized device that manages all APs on a wireless network. For larger wireless networks, multiple controllers may need to work together in a group called a 'cluster' or 'team'.

PoE - Power over Ethernet : A network switch specification that provides 15.4 Watts of power per RJ45 ethernet port to power a device. This is commonly used for APs, cameras and sometimes thin clients.

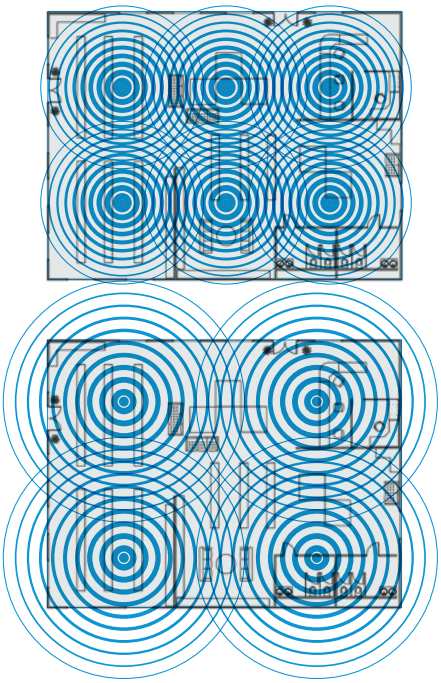
PoE+ - Power over Ethernet plus : A network switch specification that provides 30 Watts of power per RJ45 ethernet port to power a device. This is commonly used for higher power requirement APs, pan/tilt/zoom cameras and sometimes thin clients.

Redundancy : Having more than one device that is able to take over in the event of a failure.

Team : A group of devices working together. Each device has a unique configuration and set of devices it services.



- Measured in decibels (dBm), which are related to milliwatts (mW) logarithmically
- Rule of 3s: adding 3 dB doubles the power
- Rule of 10s: adding 10 dB increases the power by 10



Coverage
Providing wireless signal where it is required

Capacity
Ensuring the wireless cell can support the required throughput of clients

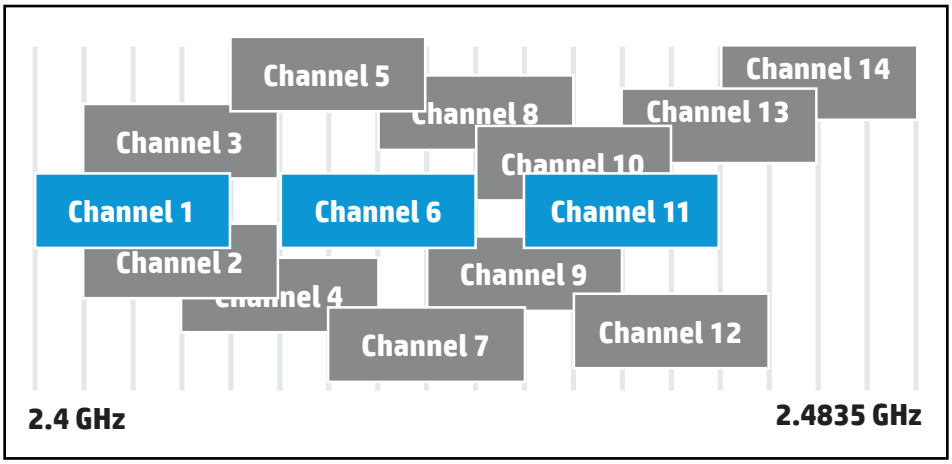
Appendix B – critical engineering concepts

More power does NOT produce a better signal. In most cases increased power decreases performance.

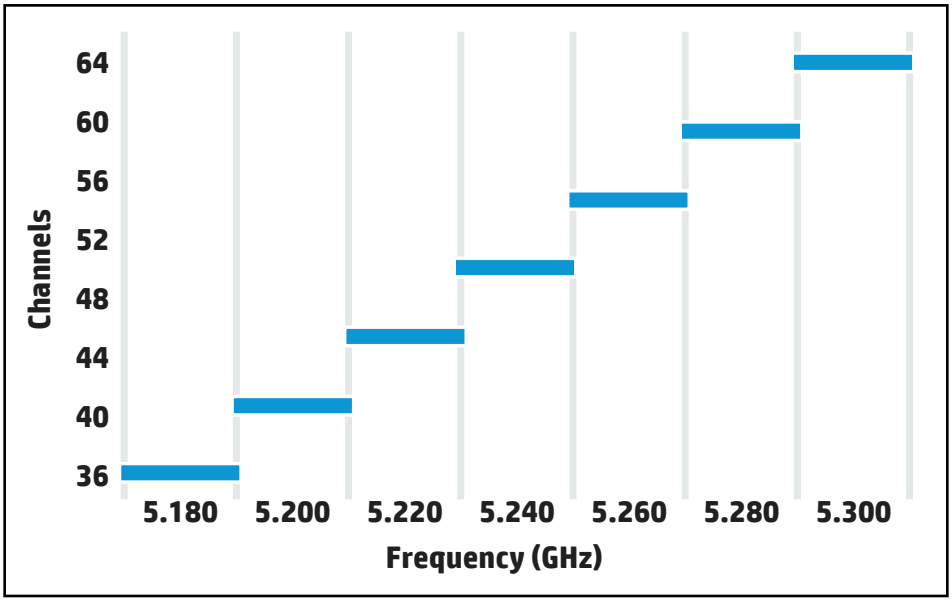
Example: If everyone in a room yells, then nobody is understood.

Released	802.11 Standard	Frequency Band	Max Data Rates*	Allowable MIMO Streams	Channel Widths	Antenna Technology
1999	802.11a	5GHz band	54 Mbit/s	1	20MHz	MIMO
1999	802.11b	2.4	11 Mbit/s	1	20MHz	MIMO
2003	802.11g	2.4	54 Mbit/s	1	20MHz	MIMO
2009	802.11n	2.4GHz & 5GHz	600 Mbps	4x4	20MHz	MIMO
2013	802.11ac	5GHz	7 Gbps	8x8	20, 40, 80, 160 MHz	MIMO, MU-MIMO

Channels in the 2.4 GHz band



Channels in the 5 GHz band



Appendix C – thin clients for one-to-one and Common Core

Summary and recommendation

HP offers a wide range of end point devices which meet the requirements set forth in the beginning of this document for standardized online testing in education. This can make decisions complex as users try to standardize across environments, while allowing for multiple types of secondary use cases & at the same time, not implementing IT solution(s) which are too difficult to deploy, support and maintain.

HP's line of thin client products can be the ideal devices to help accomplish these goals, without leading to IT sprawl or needless complexity. Choosing the right thin client device(s) does not have to be a difficult choice, as there are specific decision points which can help strategically determine how to best fit any need.

The HP t310 Zero Client device is designed only for use with VMware ESX Server environment(s) via a Teradici Tera2 Chipset. While this device is designed for uncompromised performance and higher security, it will not function in any other type of deployment and should not be considered for standardized testing, as it does not meet the requirements. It is important to note however; this is a true zero client – powered only by a Tera2 PCOIP Silicon chip. There is no component to allow for non-volatile storage, which means no local operating system or CODECs to manage or maintain. This elevates the t310 to the position of HP's most secure end point device, while providing top of the line graphical performance – making it ideal for power users. If your server environment is base on VMware ESX, this is the ideal unit to consider.

The HP t410 Smart Zero Client (Standard & All in One) devices are built based on an Ubuntu Linux Kernel, allowing it to meet the standards for online testing, while being locked down and optimized for use with remote and or cloud-based Citrix or Microsoft Server environments. At the heart of the HP t410 is the Texas Instruments System on a Chip (SOC) that integrates the ARM CPU, graphics chipset, digital signal processor (DSP), and other components in a single package. By integrating all of these traditional PC components onto a single piece of silicon and dedicating them to the performance of the remote connection – the t410 delivers an amazingly robust performance. This device should not be deployed for use without having a remote Citrix or Microsoft environment to connect into, as it does not have the capabilities required to function in a standalone manner, despite a local web browser as it allows for stripped down / minimal functionality.

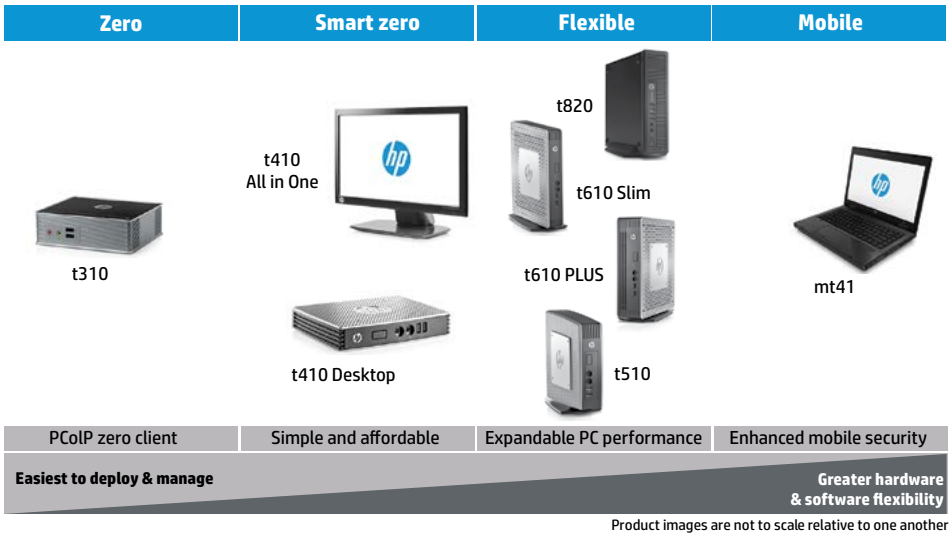
HP Flexible Series Thin Clients deliver the highest level of capabilities and functionality, and can be deployed in the widest variety of environments. With an easy set-up, flexible thin clients provide powerful performance with more security, expansion options, and a PC-like multimedia experience. While they are designed for use with remote & cloud environments, such as Microsoft RemoteFX, Citrix HDX, VMware Horizon View; local applications such as Internet Explorer help meet the requirements for standardized online testing without doing so. Reduced physical size and energy consumption – without the need to sacrifice performance – makes these ideal in education, where desk size and overall real estate is a luxury. Combining this flexibility, with a long lifespan, these devices can be reconfigured and redeployed as your environment evolves; making these the best 'bang for the buck' end point devices you can choose.

End point devices

HP offers a full range of end point devices, which meet the requirements spelled out in this Reference Architecture, at multiple levels – ranging from minimum to recommended requirements; in many cases going above and beyond to add value. This version of the reference architecture will focus solely on thin client devices, please see Figure 1 for a complete listing of thin client devices included in this document.

Figure 1

HP thin client family



Product images are not to scale relative to one another

Zero clients

Zero clients do not meet the Digital Testing Technology Requirements because they do not include a local operating system of any type. These types of devices are intended to be used in conjunction with a Virtualized Desktop Infrastructure (VDI). They are included in this document for sake of being thorough, but the key takeaway is that they are out of scope for the purposes of standardized testing, as they do not meet the minimum technical requirements for either Smarter Balanced or PARCC - spelled out earlier in this document.

Smart zero clients

Based on an Ubuntu Linux OS/kernel, HP Smart Zero clients are locked down devices that are designed for uni-tasking. Devices only capable of uni-tasking add value to standardized testing by ensuring that there are no ways to utilize other features of the device while testing. HP offers two versions of the t410 Smart Zero Client; one standard and one All in One (AiO), both of which are detailed immediately following the features at a glance.

Smart zero core features at a glance

- HP Smart zero technology, just boot and connect
- Smart Zero client experience
  - Fast boot, quick connect and responsive interaction
  - User boots into their host environment with no local desktop complexity
  - User preferences can be set and retained without leaving the login screen
  - On-screen controls are streamlined to eliminate desktop clutter
- Citrix optimization:
  - Full screen 1080P HDX multimedia capability at an affordable price
  - Dock bar for convenient access to multiple published applications
  - Smooth roaming assures that your applications follow you
- Automatic intelligence
  - Intelligence is automatically inherited by HP Smart Zero Client Services
  - Support for Broadcast and DHCP Tag to discover Smart Zero Client Services
  - Leverages remote intelligence resources to minimize desktop overhead
  - Installation wizard establishes desktop environment for all devices in minutes
  - Automatic broadcast system finds HP Smart Zero Client Services and delivers user desktop in seconds
  - Profile editor allows connection changes to be made in just a few clicks

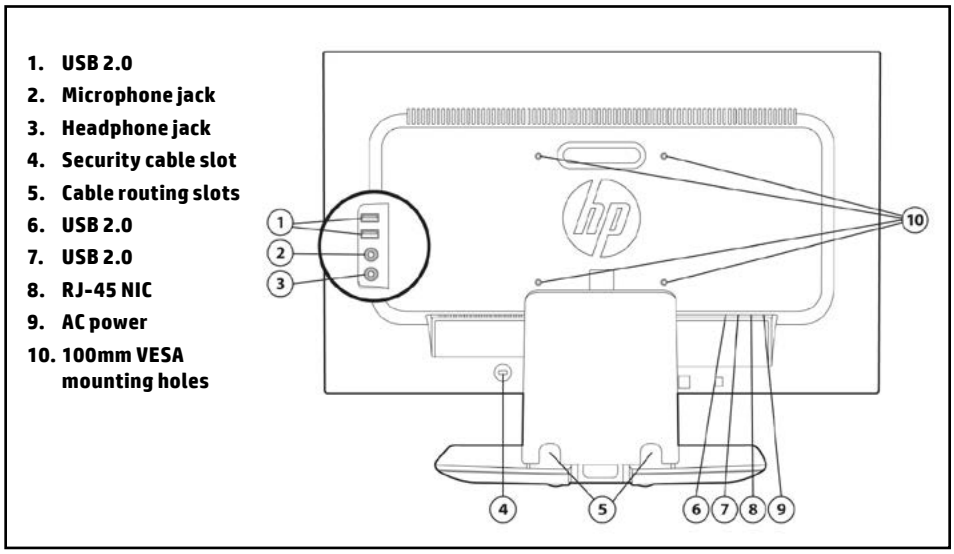
  – Seamless updates from the cloud allow users work instead of waiting for installs
- Uncompromised IT
  – Unique device purposing, choose from ICA-HDX or RDP or View with PCoIP
  – HP Smart Zero Client Services integrates with host to maintain a clean IT environment
  – Your desktop attack surface is minimized with no local apps
- Console visibility, asset information and reboot through HP Device Manager Improved quality of experience for end-user using HP Velocity
  – Available only on HP thin clients
  – HP Velocity enables IT managers to monitor network activity and optimize end-user experience
  – HP Velocity intelligently reduces network packet loss and retransmissions providing a better experience for the end-user

The t410 AiO is designed for clutter-free computing and operates at or below 13 Watts of power via Type 1 Power over Ethernet (PoE). This makes it HP's lowest power All in One device, capable of being deployed in a very high range of environments. The optional A/C attachment provides for the most flexibility, however when using the PoE – only one wire is required to power the entire device, including the 18.5" diagonal LED display. Please see Figure 2 for a visual overview of this product.

HP t410 AiO hardware features

- One wire: PoE Type-1 powering both the Smart Zero Client AND the display
- Texas Instruments TMS320DM8148 ARM® Cortex™-A8 (1 GHz, 256 KB L2 cache, 1 core) processor with Neon extensions
- 1 GB 400 MHz DDR3 SDRAM
- 2 GB eMMC Flash memory
- 10/100/1000 Gigabit Ethernet (RJ-45)
- 10/100 Ethernet when using PoE
- 4 USB 2.0 ports
- 18.5-inch diagonal WLED backlit display with 3M film-maximum resolution is 1366 x 768
- ENERGY STAR® qualified and EPEAT® Gold registered where applicable/supported. See epeat.net for registration status by country.
- BFR/PVC free
- Contains over 10% post-consumer recycled plastics (by weight) (confirmed)

Figure 2



The standard version of the t410 provides just about all of the features and benefits that the AiO version does, with a few minor and expected differences. This version does not have PoE capabilities, nor does it have a display built in. The tradeoff is that dual-video is supported on the standard version. The wattage requirements are also different, as this device does not provide power for the display. Please see Figure 3 for a visual overview of this product.

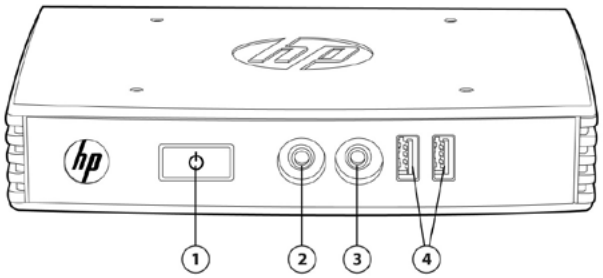
HP t410 hardware features (standard version)

- Texas Instruments TMS320DM8148 ARM® Cortex™-A8 (1 GHz, 256 KB L2 cache, 1 core) processor with Neon extensions
- 1 GB 400 MHz DDR3 SDRAM
- 2 GB eMMC Flash memory
- 10/100/1000 Gigabit Ethernet (RJ-45)
- Supports up to 2 displays, 1 VGA, 1 DisplayPort 1.1a
- Supports resolutions up to 1920x1080 (60Hz) for single and dual displays. Actual performance and resolutions available will vary depending on client virtualization protocol being used and content being displayed.
- 4 USB 2.0 ports: 1 for keyboard, 1 for mouse, 2 for other USB devices
- BFR/PVC free
- ENERGY STAR® qualified and EPEAT® Gold registered where applicable/supported. See epeat.net for registration status by country.
- Contains over 10% post-consumer recycled plastics (by weight)

Figure 3

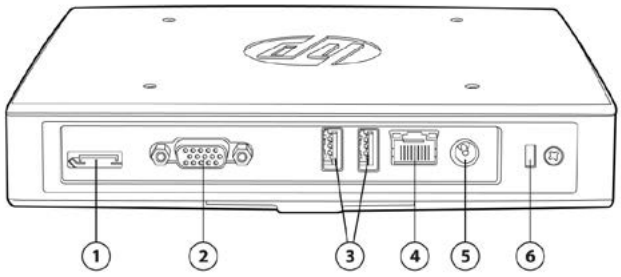
Front

1. **Power button**
2. **Headphone**
3. **Microphone**
4. **USB 2.0**



Rear

1. **DisplayPort 1.1a**
2. **VGA**
3. **USB 2.0**
4. **RJ-45 NIC**
5. **AC power**
6. **Security cable slot**



Flexible thin clients
HP Flexible Series Thin Clients combine the strongest attributes of a traditional PC, with the increased security, management capabilities and form factor benefits of our Zero and Smart Zero Thin Clients.

Whereas Zero Clients have no operating system whatsoever, and Smart Zero Clients have a locked down Linux Kernel – HP Flexible Series Thin Clients can be configured and deployed with an OS that is closer to that which would be deployed on a PC. By deploying devices in this manner; customers have more choices in how these devices are deployed and used, without sacrificing the values of our more locked down Zero and Smart Zero clients.

In order to thoroughly list all of the features and values of these devices, we must breakdown the sub-topics into two categories:

- Operating System
- Platform Form Factor

Operating system
It is important to note that all of the HP Flexible Series Thin Clients are available and are able to be deployed with all three configuration types:

- Microsoft Windows Embedded
- ThinPro Linux
- Smart Zero Core

Each one of these types brings with it unique values which will drive the decision. It is also important to note that strategically deploying a mix of these three types is common, depending on the goals and requirements set forth by the customer.

Microsoft Windows Embedded Standard (WES)
WES is a dynamic Operating System which provides a support for multiple processor architecture like x64 and x86. In this situation, we define dynamic as having the capability to actively determine specific device type(s) and to install drivers as needed to allow for expected functionality. For example, with a dynamic OS, when a user plugs in a USB key the OS is able to determine what is needed for the key to be recognized and used and it is able to complete the required steps on its own and without the need for drivers to be manually installed. This is a critically important feature in situations where device types – such as USB keys, keyboard and mouse peripherals, and others will vary by user. This is an extremely important choice point by the customer. If the intent is to require the use of 3rd party devices that will not be standardized, using a dynamic OS is the only way to guarantee success of any/all possible devices.

The WES OS is built using the same Windows kernel as the full desktop version. This is an important callout because it enables many similarities. For example, the drivers and applications for Windows 7 can work on WES 7 without the need for extensive IT efforts to integrate. It also provides support for:

- Active Directory
- Group Policies
- IPv6
- Network Access Protection

These components enable connectivity, along with manageability with Windows Server, System Center Configuration Manager and Windows Update Services, which are required in many environments to comply with IT policies in place.

In addition to applications required to connect into backend data center environments, WES devices include many other commonly used applications which are included with traditional Windows devices including:

- Internet Explorer
- Windows Media Player

- Silverlight
- Remote Desktop Protocol
- .net Framework

There are several components designed specifically for WES which provide for a more secure environment than Windows. Examples of these components include:

- Enhanced Write Filter (EWF)
- Registry Filter
- Hibernate Once Resume Many (HORM)
- Dialog Filter

The EWF for example is used to automatically discard all changes made to the device's C:\ partition upon shutdown or reboot. This is accomplished by committing any changes made to the devices Volatile memory (RAM), as opposed to its non-volatile memory (Flash/Hard Drive.)

The tradeoff for these components would prevent just about any type of normal use on a traditional PC, yet has no effect on the normal use of a thin client when deployed using recommended practices.

In addition to the benefits realized based on which applications and components are either installed or not installed, users have the added value of familiarity. WES thin clients have the same look and feel which users have come to expect from a traditional Windows desktop. Items such as the Start Button and desktop landscape are identical. This eliminates the need to train users on how to comfortably navigate and use the thin clients.

WES OS features at a glance

- Microsoft® Windows® Embedded Standard 7 SP1 with support for Remote FX and local applications, provides a richer user experience
- Supports latest Internet Explorer 8 (IE8)
- Excellent rich multimedia experience and enhanced USB device support in VDI environments
- Latest protocol support from Citrix On-Line Plug in (ICA) 13, RDP 7.1 w/Remote FX, and VMware View 5.0
- Enhanced Write Filter and File-Based Write Filter provide complete flexibility to protect the entire Flash disk, or configure areas of the disk for persistent access by local applications
- Microsoft Firewall for enhanced data security
- Support 802.1x LAN-based authentication for greater security
- HP Universal Print Driver provides instant access to a range of HP print devices without downloading separate drivers -- hp.com/go/upd
- Improved quality of experience for end-user using HP Velocity
  - Available only on HP thin clients
  - HP Velocity enables IT managers to monitor network activity and optimize end-user experience
  - HP Velocity intelligently reduces network packet loss and retransmissions providing a better experience for the end-user

ThinPro Linux

HP's ThinPro is a proprietary Linux OS, based on an Ubuntu kernel, and built specifically for use on HP Flexible Series Thin Clients. ThinPro is a static OS, as opposed to WES. In this situation, we define static as the inability to actively determine specific device type(s) or to install drivers as needed to allow for expected functionality. Using the same example as above, with a static OS, all drivers must be preinstalled in order to be able to properly use a device. If a user plugs a USB key into a ThinPro device and the drivers are preinstalled, the USB key will function properly. If the drivers are not preinstalled, the device will not function at all.

Therefore, if the intent is standardizing all users on specific types of devices, using a static OS will provide more security than a dynamic one can. However, if it is not possible to control the

standardization (i.e. requiring students to provide their own USB keys) a dynamic OS is the only way to guarantee 100% compatibility for all users.

It is also important to note – for purposes of this document – that the web browser which is pre-installed onto ThinPro OS images is a very basic version of Mozilla Firefox, which may or may not meet all of the requirements for day to day use as these will vary between environments. If connecting into a server-based environment, this is a moot point, however if the intent is to use a web browser which is installed natively on the thin client device the only real choice should be WES with the included Internet Explorer.

ThinPro Linux features at a glance

- HP ThinPro operating system provides a single console interface for dashboard visibility to all user and administrative touch points with user and administrator logins for added security.
- HP ThinPro supports modular software updates that can be applied remotely over the network with less bandwidth overhead. This type of update mechanism also improves HP's ability to deliver time-to-market client-side updates from third party software partners such as Citrix and VMware.
- ICA, PCoIP, and RDP support for accessing Windows and Citrix resources
- VDI broker support includes VMware View, Citrix XenDesktop (with CDA mode utility)
- Multimedia and USB redirection support
  - Citrix HDX MediaStream (multimedia redirection)
  - Citrix HDX Plug-n-Play (USB redirection)
  - Preinstalled Video Codecs: MPEG 1, WMV 7/8/9
  - Preinstalled Audio Codecs: MP3, WMA, ALAW, MULAW
- HP Easy Tools
  - HP Easy Setup Wizard: Guides administrators through one time setup
  - HP Easy Update: Keep your software current
  - HP Easy Config: Purpose your HP t510 as an optimized VDI appliance
  - HP ThinState: Capture your master image or settings and port to USB key or HP Automatic update repository
  - HP Automatic Update: Automate configuration changes and/or software updates to multiple devices

    NOTE: run devices in stateless mode or cache settings locally in persistent mode
- HP Device Manager simplifies visibility and management for small and large thin client deployments scattered across multiple subnets and NAT environments.
- Native HP TeemTalk terminal emulation suite and local XDMCP/X.11 for accessing legacy application resources such as mainframes and mid-range servers or Unix/Linux X-window environments.
- Improved quality of experience for end-user using HP Velocity
  - Available only on HP thin clients
  - HP Velocity enables IT managers to monitor network activity and optimize end-user experience
  - HP Velocity intelligently reduces network packet loss and retransmissions providing a better experience for the end-user

Smart Zero Core

The SmartZero Core was detailed extensively above in the section entitled Smart Zero Clients. Recapping, this is a device which is intended for uni-tasking and for connection into a server-based environment which is driven by Microsoft, Citrix or VMware.

Platform form factor
There are four different thin clients which HP classifies as part of the Flexible Series. These are:

t510
The HP t510 Flexible Thin Client combines smart design with built-in efficiency delivering a productive desktop experience. Native dual DVI video, combined with legacy serial and parallel ports allows for deployment in just about any environment, from back office to customer facing. Please see Figure 5 for a visual overview of this product.

- **t610 / t610 PLUS**
  The HP t610 Flexible Thin Clients deliver a true, PC-like experience for virtualized desktop environments. Built using AMD's new APU technology, the HP t610 combines dual core 64-bit processors and AMD HD 63202 graphics. Both thin clients feature DirectX 11 graphics support, DDR3-1600 RAM with up to 8 GB of capacity and AMD A55E Chipset with DVI-I and DisplayPort outputs for exceptional performance. Please see Figures 6-a through 6-d for a visual overview of these products.

- **t820**
  HP's most powerful thin client is the full-featured solution to boost efficiency and performance. Get a responsive, smooth desktop experience from two Intel® 4th Generation high performance processors. Robust security options deliver superior data protection. This top of the line product combines the power of a high performance workstation, with the security and simplified management of a thin client; truly the best of both worlds. Deploy with up to seven displays at 1900x1200 resolutions, or four displays at 2500x1600 resolutions. Please see Figures 7-a & 7-b for a visual overview of this product.

- **mt41**
  This is HP's mobile thin client, providing all of the same features and benefits of our other Flexible Series devices, combined with HP's leading mobility engineered design, form factor and supported devices. This device is ideal for not only standardized testing, but also for the added requirements which drives customers towards mobile devices, all within an enterprise-grade durable design. Please see Figures 8-a through 8-c for a visual overview of this product.

HP t510 hardware features
- VIA Eden X2 U4200 (1 GHz, 2 cores) processor for great performance
- VIA VX900 chipset
- 2 GB 1066 MHz DDR3 RAM (128 MB reserved for video)
- 1, 2 or 4GB Flash memory (depending on operating system) provides ample storage for applications and drivers
- 6 USB 2.0 ports
- Secure USB compartment is ideal for protecting USB wireless and USB Flash devices or for securing USB keyboard and mouse
- Legacy support includes parallel, serial, and PS/2 connections
- Built in dual monitor support (DVI-I and DVI-D native, with DVI-I-to-VGA adapter included in carton)
- ENERGY STAR® qualified and EPEAT® Gold registered where applicable/supported. See epeat.net for registration status by country.
- BFR/PVC free
- Contains over 10% post-consumer recycled plastics (by weight)

Figure 4

1. Secure USB compartment
2. Power button with LED
3. Flash storage activity indicator
4. Audio connector (mic in)
5. Audio connector (headphone out)
6. USB connectors (2)
7. Vertical stand (removable)
8. Insertion points for self-adhesive feet
9. VESA mounting points (4)

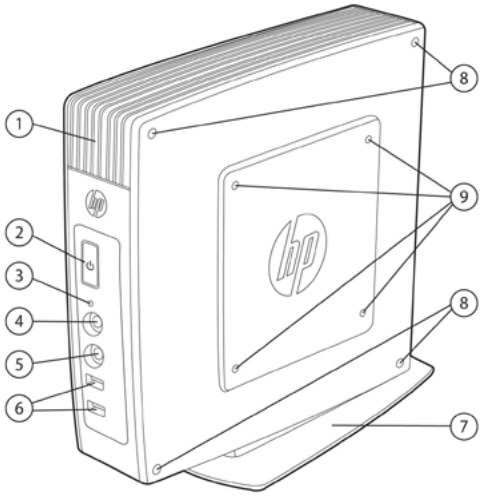
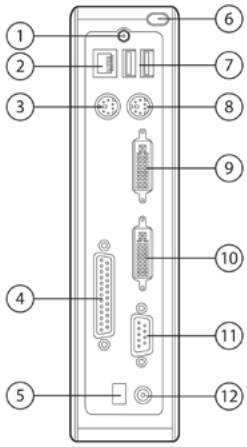


Figure 5

1. Integrating wireless connector (available on some models)
2. 10/100/1000 Ethernet RJ-45 connector
3. PS/2 mouse connector
4. Parallel port
5. Power cord retention slot
6. Cable routing from secure USB compartment
7. USB connectors (2)
8. PS/2 keyboard connector
9. DVI-D connector
10. DVI-I connector
11. Serial port
12. +19vDC power input



HP t610 / t610 PLUS hardware features

- Two chassis: Standard (slim) and PLUS (expansion)
- AMD G-Series T56N 2nd generation 1.65 GHz dual-core 64-bit accelerated processing unit (APU) for excellent processing and graphics performance
- AMD Radeon HD 6320 integrated graphics with hardware acceleration of streaming video formats, DirectX 11 support, DVI-I and DisplayPort 1.1a video ports, DVI-to-VGA adapter included, supports video resolutions up to 2560x1600
- DDR3-1600 SODIMM (two slots) up to 4 GB supported (running at 1333 MHz)
- Active thermal management monitors component operating temperatures, throttles APU operation if appropriate, and prevents unit thermal shutdown
- HP t610 PLUS factory-installed quad-head video option: Dual-head AMD FirePro 2270 video card which, when combined with onboard video ports, provides up to 4 digital video ports output (WES 7 quad-head configurations require 4 GB RAM): Up to four digital monitors at 1920x1200 through one DisplayPort video port plus three DVI-I video ports or up to three digital monitors at 2560x1600 (using optional DMS-59-to-DisplayPort adapter)
- HP t610 PLUS factory-installed up to six-head video option: Quad-head AMD FirePro 2460 video card which, when combined with on-board video ports, provides up to 6 digital video ports output (WES 7 quad-head configurations require 4 GB RAM): Up to six digital monitors at 1920x1200 through one DVI-I video port and five DisplayPort video ports, or up to four digital monitors at 2560x1600
- LAN - 10/100/1000 Mb/s Ethernet Wi-Fi option: 802.11 a/b/g/N internal (Broadcom mini-PCIe) module plus dual internal antennas for superior performance and security
- USB ports: 2 x USB 2.0 on front, 2 x USB 2.0 on rear, and 2 x USB 3.0 on rear
- Legacy ports standard: PS/2 keyboard and PS/2 mouse, and 1 x Serial
- Legacy ports PLUS: PS/2 keyboard and PS/2 mouse, 2 x Serial, and 1 x Parallel
- Security features: TCG certified TPM chipset, BIOS designed to address NIST SP 800-147 guidelines, cable lock slot, and power cord retention slot to prevent accidental disconnects
- HP t610 PLUS expansion: Half-height PCI Express x4 (physically x16) expansion slot (not available with quad-head or six-head digital monitor configurations)
- Multiple solid-state drive options
- Qualified 3rd-party Fiber NIC PCIe card options (Allied Telesis)
- HP 100 Mbps Mini PCIe SC Fiber NIC factory-installed option on HP t610 PLUS (leaves PCIe slot open for video or other expansion cards)
- ENERGY STAR® qualified and EPEAT® Gold registered where applicable/supported (except for models with quad-head or six-head video option installed). See epeat.net for registration status by country.
- Post-consumer recycled plastics content greater than 20% total unit plastics (by weight)
- Low halogen
- All models TAA Compliant (in North America)

Figure 6-a

1. **Power button (with integrated power indicator light)**
2. **Flash drive activity indicator light**
3. **Audio connector (mic/line in)**
4. **Audio connector (headphone/ line out)**
5. **USB 2.0 connectors (two)**
6. **Removable stand for vertical orientation**
7. **Mounting points for HP Quick Release or other VESA mount**

Figure 6-b

1. **Mounting location for four horizontal mounting feet**
2. **DVI-I monitor out**
3. **DisplayPort 1.1a monitor out**
4. **Ethernet RJ-45 connector**
5. **USB 2.0 connectors (two)**
6. **USB 3.0 connectors (two)**
7. **Serial connector**
8. **PS/2 keyboard connector**
9. **PS/2 mouse connector**
10. **+19V DC power input**
11. **Power cable retention slot**
12. **Cable lock slot**

Figure 6-c

1. **Power button (with integrated power indicator light)**
2. **Flash drive activity indicator light**
3. **Audio connector (mic/line in)**
4. **Audio connector (headphone/line out)**
5. **USB 2.0 connectors (two)**
6. **Removable stand for vertical orientation**
7. **Mounting points for HP Quick Release or other VESA mount**

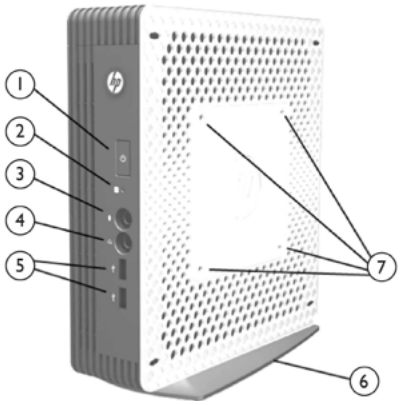
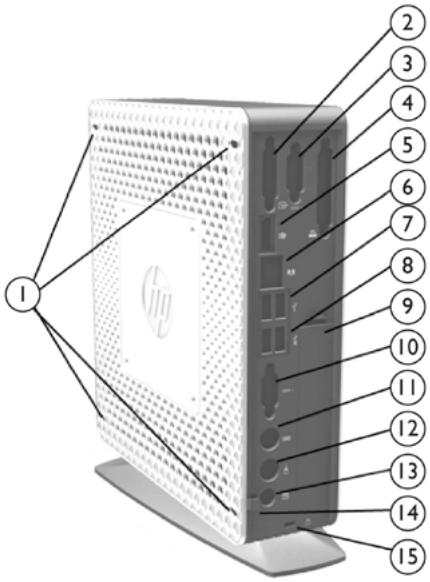


Figure 6-d

1. **Mounting location for four horizontal mounting feet**
2. **DVI-I monitor out**
3. **Serial connector**
4. **Parallel connector**
5. **DisplayPort 1.1a monitor out**
6. **Ethernet RJ-45 connector**
7. **USB 2.0 connectors (two)**
8. **USB 3.0 connectors (two)**
9. **PCI Express (half-height) card slot (in quad-head video configurations - 2 x DVI-I ports)**
10. **Serial connector**
11. **PS/2 keyboard connector**
12. **PS/2 mouse connector**
13. **+19V DC power input**
14. **Power cable retention slot**
15. **Cable lock slot**



HP t820 hardware features

- Choice between two powerful 4th generation Intel CPUs for handling the most demanding client virtualization environments (Citrix HDX including HDX 3D Pro, VMware Horizon View, and Microsoft Remote FX)
- Intel Q87 Express chipset supporting Intel 4th generation Core processors, featuring integrated Intel HD 4600 Graphics and vPro Technology (available with select processors)
- Discrete graphics option available featuring Multi-Stream technology with support for up to seven (7) Full HD (1920x1080) using optional HP DisplayPort 1.2 Hubs
- Wi-Fi option: 802.11 a/b/g/n mini-PCIe internal module with dual internal antennas for enterprise-class performance and security
- Fiber networking option: HP Mini PCIe 100 Mbps SC Fiber NIC factory-installed option
- Security features: TCG certified TPM chipset, BIOS designed to address NIST SP 800-147 guidelines, cable lock slot, lockable rear port cover option, case intrusion detection option, and Intel vPro/SIPP capabilities with Core i5 CPU.
- New, progressive commercial design
- HP developed and engineered UEFI BIOS for better security, manageability and software image stability
- Intel Clarkville i217LM GbE LOM integrated network connection
- DDR3 Synchronous Dynamic Random Access Memory (SDRAM)
- Dual digital monitor support via dual integrated DisplayPort ports (supports DisplayPort 1.2)
- 87% efficient energy saving external power adapter standard
- ENERGY STAR® qualified models certified EPEAT® Gold
- Created using industry leading Design for Environment standards
- Low halogen design*
- Protected by HP Services, including standard warranties up to 3-3-3 (terms and conditions vary by country; certain restrictions and exclusions apply)
- Tool-less serviceability features for easier upgrades and repairs
- All models TAA Compliant (in North America)
- This product is low halogen except for power cords, cables and peripherals, as well as the customer-configurable 100 Mbps Fiber NIC module which are not Low Halogen. Service parts obtained after purchase may not be Low Halogen.

* The antennas are not visible from the outside of the computer. For optimal transmission, keep the areas immediately around the antennas free from obstructions.

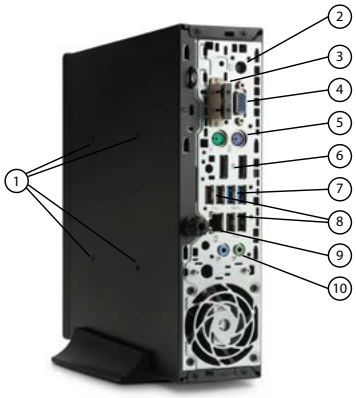
**Models without optional webcam have a single integrated microphone on left side of display panel.

Figure 7-a

1. **USB 2.0 connectors (two)**
2. **USB 3.0 connectors (two)**
3. **Audio connector (microphone / headset out)**
4. **Audio connector (speaker / headset out)**
5. **Flash drive activity indicator light (not called-out in image above)**
6. **Power button (with integrated power indicator light)**
7. **Mounting points for HP Quick Release or other VESA mount**

Figure 7-b

1. **Mounting points for HP Quick Release or other VESA mount**
2. **Power in (from external power supply)**
3. **SC Fiber Network Connector (optional)**
4. **VGA monitor out**
5. **PS/2 keyboard and mouse connectors**
6. **DisplayPort 1.2 connectors (two)**
7. **USB 3.0 connectors (two)**
8. **USB 2.0 connectors (four)**
9. **10/100/1000 Mbps Ethernet RJ-45 port**
10. **Audio connectors (line in / line out)**

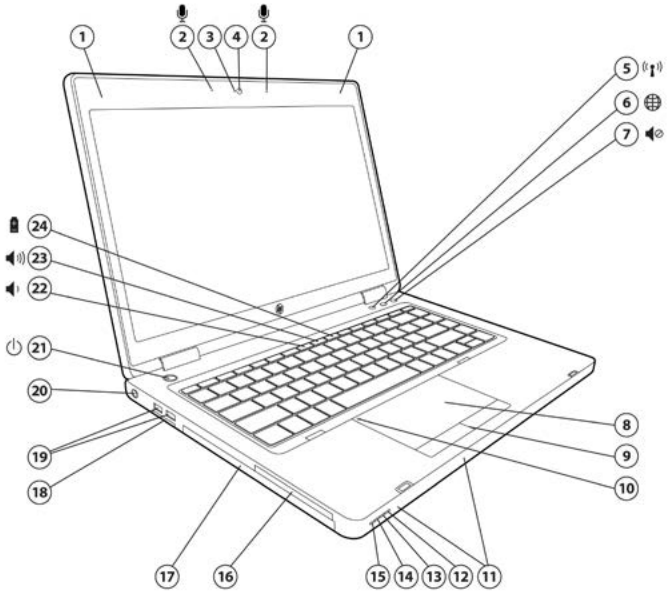


HP mt41 hardware features

- Windows Embedded Standard 7e (WES7E 32-bit)
- 14.0-inch diagonal LED-backlit HD anti-glare display (1366 x 768)
- Administrator control over read/write access to Solid State Drive and USB attached memory devices
- Weight starting at 4.59 lb (2.08 kg)
- 16GB Solid State Drive for reliability, durability, and increased battery life
- Full-sized spill-resistant keyboard with bottom-case drain, touchpad with scroll zone and gestures support, discrete buttons,
- WLAN on/off and mute
- Choice of primary battery to optimize run-time or weight: 9-cell (100 WHr) or 6-cell (55 WHr)
- Easily hot dock with the optional HP docking station
- HP Device Manager to track, configure, upgrade, clone and manage hundreds or thousands of thin clients
- Improved quality of experience for end-user using HP Velocity
  - HP Velocity intelligently reduces network packet loss and retransmissions providing a better experience for the end-user
  - HP Velocity enables IT managers to monitor network activity and optimize end-user experience
  - Available only on HP thin clients
- VGA and DisplayPort v1.2 for dual external-monitor support, including high-definition displays

- Flexible wireless connectivity options:
  - HP Connection Manager allows full control over wireless connections, including 3G and 4G mobile broadband
  - Integrated 3G/4G HP Mobile Broadband Modules
  - Integrated 802.11 a/b/g/n wireless LAN module
- Integrated Secure Digital slot (supports SD, SDHC, SDXC)
- Optional integrated DVD-ROM drive
- Optional webcam

Figure 8-a



1. **WLAN antennas (2)***
2. **WWAN antennas (2)***
3. **Internal microphone array (2)****
4. **Webcam light (select models only)**
5. **Webcam (select models only)**
6. **Internal display switch**
7. **Wireless button**
8. **Volume mute button**
9. **Touchpad buttons**
10. **Touchpad zone**
11. **Hard drive light**
12. **AC adapter/Battery light**
13. **Power light**
14. **Wireless light**
15. **Smart card reader**
16. **Optical Drive (select models only)**
17. **USB 2.0 port (1)**
18. **Secure digital slot**
19. **USB 2.0 charging port (1)**
20. **RJ-45 (network) jack/lights**
21. **Power connector**
22. **Power button**
23. **Volume**
24. **Battery**

* The antennas are not visible from the outside of the computer. For optimal transmission, keep the areas immediately around the antennas free from obstructions.

**Models without optional webcam have a single integrated microphone on left side of display panel.

Figure 8-b

1. **Audio-out (headphone) jack / Audio-in (microphone) jack**
2. **USB 2.0 ports (2)**
3. **DisplayPort 1.2**
4. **External VGA monitor port**
5. **Vents (2)**
6. **Security cable slot**
7. **Activity indicator light**
8. **VGA monitor out**
9. **10/100/1000 Mbps Ethernet RJ45**

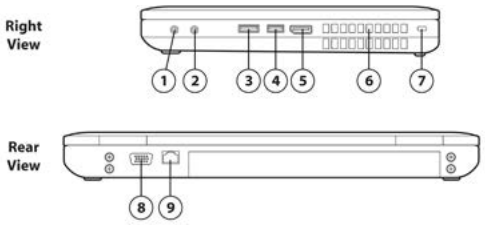
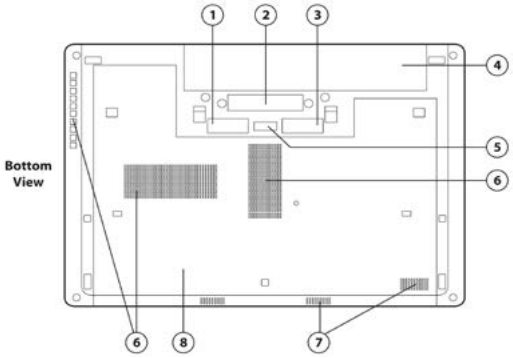


Figure 8-c

1. **Service cover**
2. **Battery release latch**
3. **SIM card slot**
4. **Docking connector**
5. **Service cover release lock**
6. **Service door release latch**
7. **Battery bay**
8. **Vents**



Key takeaways

For the majority of users, HP's Flexible Series Thin Clients, deployed with a Windows Embedded Operating System, are the ones best suited for deployment into education environments where standardized testing is a primary or secondary use case. Deploying this configuration will guarantee 100% device compatibility, aligned with traditional PC devices, for example USB thumb drives. Local application support such as Internet Explorer, which is preinstalled and included, allows for use with standardized testing in environments where remote or cloud-based options are not available.

Customers who are able to take advantage of remote and/or cloud environments may prefer to deploy either ThinPro Linux or Smart Zero to meet their needs. Depending on other intended use cases and requirements for these devices, this is a viable approach and one that meets the online standardized testing requirements for end point devices. In these scenarios there are more moving parts required for full functionality, such as multimedia and USB redirection technologies. The success will depend on the customer environment and a thorough evaluation is recommended before deployment into production use.

Zero clients do not meet the requirements for online standardized testing because they do not have a local Operating System or storage capabilities and are therefore out of scope for this use case.

For more information on HP Thin Clients and to request units for evaluation, please visit hp.com/go/thincomputing

Or contact your HP account manager or authorized reseller

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4AA5-0015ENUS, November 2013