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White Paper

Designing an IP Network for PDi Computer Modules

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Introduction

Today's hospital-grade TV is more than a patient amenity—it is an important factor in the total patient experience. To optimize that experience the network approach must take into account all the factors that affect quality of service.

This paper provides guidance on how to estimate bandwidth requirements to provide an acceptable level of performance within a budget.

Designing a network infrastructure to accommodate PDi healthcare television IPTV/computer modules (hereon referred to as computer modules) is very similar to designing a network for a group of desktop or laptop computer users. Building the system to handle the absolute maximum bandwidth demands of all computer modules will almost always be cost prohibitive. The solution lies in accounting for the factors that affect quality of service, then making an optimized compromise between cost and performance.

Design Process

PDi televisions are designed to accept one of various PDi computer modules. These computer modules are similar to a laptop computer motherboard inside a specially designed chassis. When connected to a television, the television becomes the computer monitor, and optionally, a touchscreen interface. PDi computer modules use industry standard Ethernet and TCP/IP protocols so they can integrate into an existing or new network. When integrated into an existing network, consider current network demands so the additional resources do not adversely affect performance. When designing a new network, consider future expansion as well as the growing need for increased bandwidth from existing users.

The first step in designing the network is to determine how the network will be used. The following questions will help determine bandwidth requirements.

- How many computer modules will be connected to the network (LAN) within one building?
- How many will be in service at any given time?
- How many patients will use the computers during peak times?
- What type of content will be viewed by the patients?
- Will internet browsing be allowed?
- Will browsing be filtered?
- Will on-site streaming video servers be deployed?

Bandwidth

Bandwidth is measured in kilobits per second and is probably the single most important factor in determining the type and cost of components needed to build a network. All networked components are connected via wired or wireless connections called "links". The link data rate, or link rate, describes the maximum bandwidth that is supported on that link. Like a chain, the slowest link rate between a server and computer module determines the maximum bandwidth available between the two.

Typical bandwidth requirements based on content type are shown in Table 1. If the network supports internet browsing, then the type of content viewed will vary widely. Small web pages like email portals will consume much less bandwidth than streaming videos from sites like YouTube. And if an internal server or servers are utilized to provide full screen streaming video, the bandwidth rises even higher.

Table 1 – Typical bandwidth requirements

Content	Typical Bandwidth
Web browsing without streaming video content[1]	80 kbit/s
Streaming video from a web server	150 – 1500 kbit/s
Streaming video from local server	500 – 2000 kbit/s
Streaming video from headend IPTV modulator[2]	1500 – 7500 kbit/s

Selecting Network Components

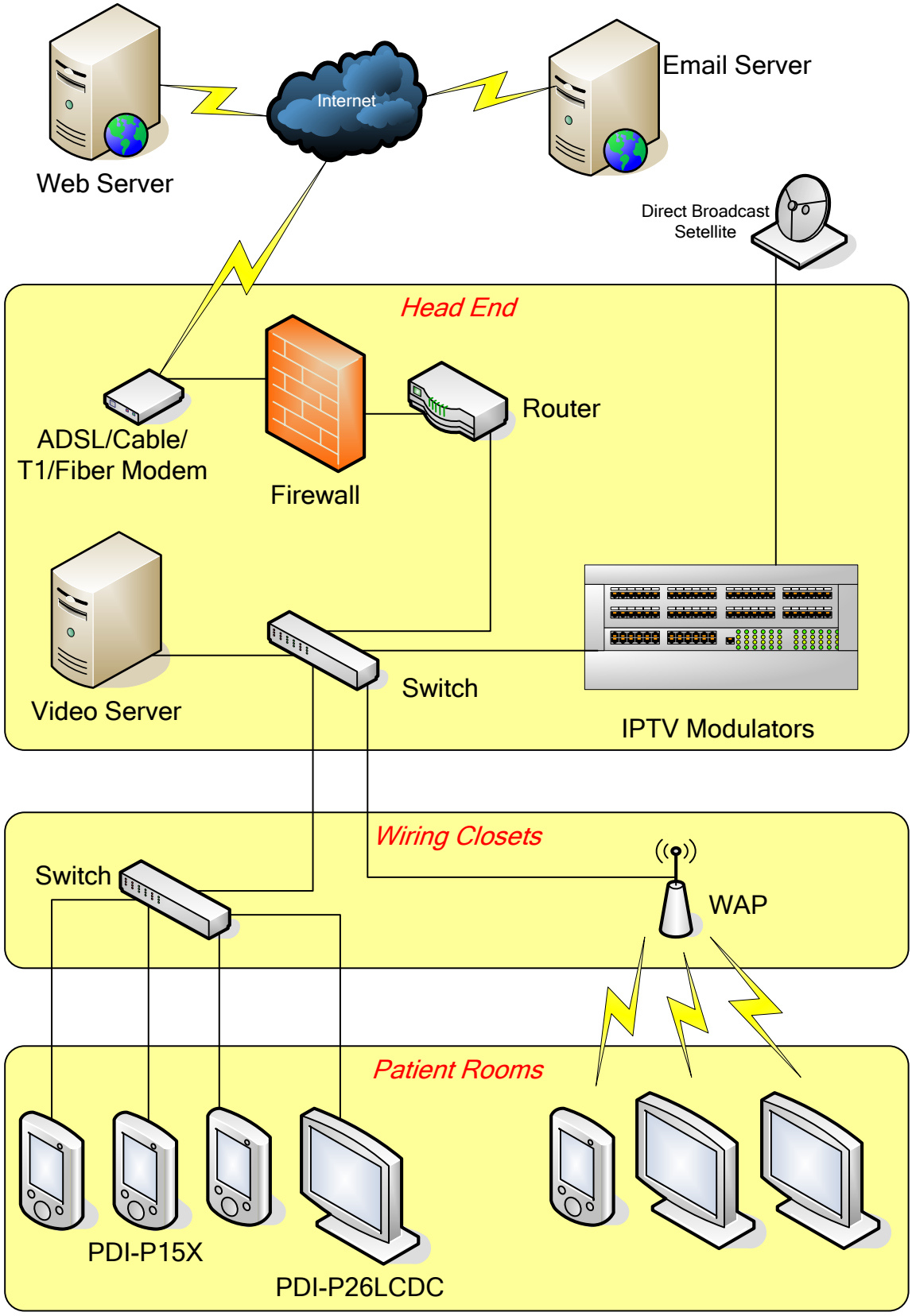
Fig. 1 shows a basic network infrastructure typical of a small healthcare facility. All components within the building are connected via network switches and wireless access points (WAP). At the bottom are shown PDi televisions. They may be attached to the network via wired or wireless connections. Everything inside the building is connected to the outside world via an internet service provider (ISP). A firewall is added for security and content filtering. The router logically separates the external internet from the internal LAN.

While the link rate of each computer module's connection will range from 10Mbit/s to 1000Mbit/s, actual bandwidth needs for individual modules will rarely exceed the slowest connections. 1Mbit/s = 1,000kbit/s. For wired connections, CAT5e or better cabling is recommended because it can handle up to 1000Mbit/s link rates and is comparable in cost to slower CAT5. For wireless [54Mbit/s (802.11g) or faster], wireless access points are recommended. Actual available bandwidth is typically lower than the stated maximum due to RF interference and protocol overhead.

[1] Based on loading an average size web page every 30 seconds. Average size given at http://www.websiteoptimization.com/speed/tweak/average-web-page/

[2] Based on stated bandwidth usage of Blonder Tongue IPME-2 IP Video Encoder.

Fig 1. – Example Network Infrastructure Supporting PDi Televisions



If using wired connections, deciding upon the type and actual model of network switch requires usage estimation. For the switches in each wiring closet, the link rate to each computer module (downlink) is usually not a limiting factor, as stated above. However, the uplink speed may be a factor because it typically has to handle the combined bandwidth of all the downlink ports. To determine the uplink requirement, add the expected usage of each downlink port. For example, the following assumptions are made:

- 20 computer modules connected to a 24-port switch in the wiring closet
- The switch in the wiring closet connects to the switch at the head end
- No other computer terminals, laptops or devices are connected to the switch
- Expected peak number of simultaneous users is n=15 (or 75%)
- Of the users online,
    - $p_{iptv} = 40\%$ are expected to be viewing video from an IPTV modulator
    - $p_{localvideo} = 10\%$ are expected to be viewing video from a local server
    - $p_{webvideo} = 25\%$ are expected to be viewing video from the web
    - $p_{email} = 25\%$ are expected to be reading email
- Viewing IPTV requires $b_{iptv} = 3500 kbit/s$
- Viewing local video requires $b_{localvideo} = 2000 kbit/s$
- Viewing web video requires $b_{webvideo} = 1000 kbit/s$
- Viewing email/general web surfing requires $b_{email} = 80 kbit/s$

The resultant demand on the switch's uplink, converted to Mbit/s is then:

$$\frac{n\left[\left(p_{iptv} \times b_{iptv}\right) + \left(p_{localvideo} \times b_{localvideo}\right) + \left(p_{webvideo} \times b_{webvideo}\right) + \left(p_{email} \times b_{email}\right)\right]}{1000} = b_{total} Mbit/s$$

$$\frac{15\left[\left(0.40 \times 3500\right) + \left(0.10 \times 2000\right) + \left(0.25 \times 1000\right) + \left(0.25 \times 80\right)\right]}{1000} = 28.05 Mbit/s$$

So a typical switch's 100Mbit/s uplink port should be adequate in this situation.

Now suppose the requirement is for all 20 users to be able to stream video from the IPTV modulators. The demand on the uplink is now:

n=20

$p_{iptv} = 100\%$

$$\frac{20 \times 3500}{1000} = 70.0 Mbit/s$$

At this usage rate, inherent network overhead may push a switch's 100Mbit/s uplink to near capacity. If any users are to be added in the future, the uplink requirement may exceed 100Mbit/s. In this case a switch with 1000Mbit/s uplink port may be desirable now because without it a new switch would have to be purchased in the future.

If wireless connections were used in place of the wired connections in both cases above, a single 802.11g WAP would not be acceptable. This is because the typical wireless throughput rate[3] of 802.11g is only 22Mbit/s. In these situations an 802.11n WAP or multiple 802.11g WAPs should be deployed to obtain adequate throughput.

Now that the networking components for most of the building is defined, the head end switch or switches must be selected to meet the demands of all downstream switches as well as local servers, IPTV modulators, etc. Check with the manufacturers of these devices to determine their requirements. It is likely that the head end switch will need a 1000Mbit/s port for each video server connected to the network. IPTV modulators typically require a 100Mbit/s port on the switch. And every wiring closet switch and WAP will need a port at the head end at the uplink rate determined in the preceding section.

Sizing the WAN / ISP Connection

If users will be able to browse the internet, speed and security are the primary concerns. At this point, an estimate of the connection speed can be easily achieved by adding the assumed internet bandwidth usage of all the users. This is a similar calculation to the one described earlier for determining the type of switch or WAP. All the users in the building must be considered, but only their internet usage will matter. For example there are 100 computer modules connected to the entire network within the building, and the following assumptions are made:

- No other computer terminals, laptops or devices are accessing the internet
- Expected peak number of simultaneous users is n=75 (or 75%)
- Of the users online,
    - 50% are viewing IPTV or local server content such as streaming video, which requires no internet connectivity
    - $p_{webvideo} = 25\%$ are viewing video from the web
    - $p_{email} = 25\%$ are reading email
- Viewing web video requires $b_{webvideo} = 1000 kbit/s$
- Viewing email/general web surfing requires $b_{email} = 80 kbit/s$

[3] Wireless networking in the Developing World (http://wndw.net/pdf/wndw2-en/wndw2-ebook.pdf)

The resultant demand on the ISP's data link, converted to Mbit/s is then:

$$\frac{n[(p_{webvideo} \times b_{webvideo}) + (p_{email} \times b_{email})]}{1000} = b_{total} Mbit/s$$

$$\frac{75[(0.25 \times 1000) + (0.25 \times 80)]}{1000} = 20.25 Mbit/s$$

In this case, with network overhead, a connection with a greater than 20.25Mbit/s download rate would be the minimum speed to request from the ISP. Some WAN connections are asymmetrical, meaning the download and upload rates are not the same. So the necessary upload rate should be determined by the ISP. Business class ISPs will give guidance as to cost/benefit analysis of various connection speed technologies.

Finally, a router, gateway, firewall, and other network peripherals must be chosen to meet the security and functional requirements of the network. The functionality and benefits of these devices are beyond the scope of this white paper. Look to the ISP or the information technology department at the facility to help in this area.

Conclusion

Today's hospital-grade TV is more than a patient amenity—it is an important factor in the total patient experience. To optimize that experience the network approach must take into account all the factors that affect quality of service, and then seek the best compromise between cost and performance.

Patients appreciate streaming video performance that is similar to a television signal. If the actual usage requirements of the total network are estimated properly, this level of service can be achieved.

PDi *provides the full spectrum of healthcare-grade televisions and accessories. Healthcare television equipment is our only business. Our national network of qualified distributors can assist you in specifying and installing scalable audio visual systems that not only meet today's requirements but are flexible enough to address your needs well into the future.*

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