Design Implications of Rich Media (Podcasting) in a Campus Network
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Design Implications of Rich Media (Podcasting) in a Campus Network

This document outlines the Cisco-recommended design for a media-ready network that can support podcasting applications in educational networks. This design can help ensure that any additional network resources required are cost-effectively implemented and integrated with the existing network infrastructure. It is written for educational and information technology (IT) professionals who need to understand the effect of podcasting on network resources. This document includes the following sections:

- Educational Podcasting
- Hierarchical Network Design Overview
- Network Design Implications and Considerations
- Podcasting and its Impact on Campus Design
- Summary

Educational Podcasting

This section summarizes the technology and applications that are enabling and driving the use of rich media in educational environments. It includes the following topics:

- Podcasting
- iTunes U
- Podcast Producer
- Impact on Higher Education

Podcasting

A podcast is audio or visual content that is automatically delivered over a network through subscription. Once a student subscribes to the podcast, the media can be regularly distributed over the Internet or within the school network and accessed with an iPod, notebook, or desktop computer (both Macs and PCs).
When new content becomes available, the new files can be automatically downloaded to the subscribers. Unlike radio or web streaming content, podcasts are not designed for real-time broadcasting. The content is prerecorded so that users can download and play the material at their leisure, independent of network connectivity.

iTunes U

On May 30, 2007, Apple announced the launch of iTunes U, a dedicated area within the iTunes Store (www.itunes.com). This area features free content including course lectures, language lessons, lab demonstrations, sports highlights, and campus tours provided by leading US colleges and universities including Stanford University, UC Berkeley, Duke University, and MIT.

Created in collaboration with colleges and universities, iTunes U makes it easy for students and other learners to extend learning, explore interests, learn more about a school, and stay connected with their alma mater. Content from iTunes can be loaded onto an iPod with a single click and experienced on-the-go, anytime, making learning from a lecture as simple as enjoying music.
The millions of people who already obtain music, movies, and TV shows at the iTunes Store can now easily obtain content developed and distributed by educational communities. iTunes U makes it easy for students to search thousands of audio and video files from schools across the country, while giving educational institutions an effective way to distribute audio and video content to students. With downloadable presentations, performances, lectures, demonstrations, debates, tours, and archival footage, school is about to become a much more inspiring place to learn.

To participate, colleges and universities build their own iTunes U sites and then link these sites to the iTunes Store. Faculty can easily post content created for their classes, while students can download what they need when they need it—empowering them to learn at any place and at any time.

Already, more than half of the nation’s top 500 schools use iTunes U to distribute their digital content to students—and to the world. Each participating school can open all or part of its site to the public, from alumni and parents to anyone with a love of learning. iTunes U is rapidly transforming the way people learn—on and off campus.

**Podcast Producer**

Apple Podcast Producer is a complete, end-to-end solution for encoding, publishing, and distributing high-quality podcasts that is ideal for publishing lectures and other educational content. Podcast Producer simplifies the process of recording, encoding, and publishing podcasts for playback in iTunes and on iPod, iPhone, and Apple TV.

**Figure 2  Apple OS 10.x with Podcast Capture**

Apple OS 10.X, released in October 2007, includes the Podcast Capture application for capturing and uploading content to Podcast Producer. Podcast Capture makes it easy to capture high-quality audio and video from local and remote cameras, record screen captures, and upload existing content into Podcast Producer for encoding and redistribution.

Podcast Producer simplifies podcast creation, production, and distribution, making it a simple and intuitive process. Workflows can be used to automate all aspects of podcasting:
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Impact on Higher Education

Given this extraordinary new opportunity for enriching education, many educational institutions are planning to use podcasting as an integrated method for creating and distributing lectures, classes, and other media-rich content.

For example, the University of California, Berkeley, and Arizona State University have recently demonstrated how podcasting MP3 audio and h.264 MP4 video can enhance the educational experience. However, institutions must work effectively with IT organizations to ensure a high-quality experience for both faculty and students. Integrating rich media into the educational experience adds a significant load to the network. Analysis and design is required to ensure that network resources can reliably meet the requirements of widespread deployment of educational podcasting. The following sections describe some general design implications and recommendations that can provide a useful starting point for discussion and design.

Hierarchical Network Design Overview

With emerging technology, such as educational podcasting, it is important to understand the underlying application requirements so that the network architecture can be evaluated and modified as required to provide the required resources and services.

Before exploring the impact of podcasting on the network architecture, it is useful to review the general principles of good network design. The Cisco Reference Network Architecture provides a hierarchical model with a modular topology using scalable “building blocks.” This architecture allows the network to meet evolving application requirements. The Cisco Reference Network Architecture is illustrated in Figure 3.

Cisco introduced this hierarchical design model, which uses a layered approach to network design, in 1999. Since then, this model has been widely deployed and validated with high-performance networks in a broad spectrum of industries, and with a wide variety of vertical applications.

The building block components, as shown in Figure 3, are as follows:

- Access layer
- Distribution layer
- Core (backbone) layer

A modular design makes the network easy to understand, troubleshoot, and scale, and helps ensure deterministic traffic patterns. In this layered, hierarchical design, the capacity, features, and functionality of each device are optimized for its position and role in the network. This promotes scalability and stability. The number of flows and their associated bandwidth requirements increase as

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they traverse points of Aggregation and move up the hierarchy from Access to Distribution to Core. Functions are distributed accordingly at each layer. A hierarchical design avoids the complexity of a fully-meshed network, in which all network nodes must be interconnected to each other.

**Figure 3  Cisco Reference Network Architecture**

The building blocks used in a modular network are easy to replicate and expand. There is no need to redesign the entire network each time a module is added or removed. Distinct building blocks can be put into service and removed from service without affecting the rest of the network. This capability facilitates troubleshooting, problem isolation, and network management.

For more details on the design and implementation of this hierarchical, modular, and structured campus architecture refer to the following design guides, available from the Campus link at www.cisco.com/go/srnd:

- Designing an Enterprise Campus Network for High Availability
- HA Campus Recovery Analysis
- High Availability Campus Network Design – Routed Access Layer using EIGRP or OSPF
Network Design Implications and Considerations

A typical podcasting solution contains four phases, each of which has different utilization and resource requirements. The total time to complete each of these phases determines the turnaround time between recording the content and availability for viewing by students. To meet your target turnaround time in the most cost-effective way, you should analyze and optimize the network infrastructure that is involved with the completion of each phase.

This section describes the network design implications and considerations associated with each phase and includes the following topics:

- Capturing and Recording Content
- Packaging Content
- Distributing and Staging Content
- Accessing and Downloading Content

Capturing and Recording Content

The following factors affect the time required to complete the capture and recording phase:

- File Transmission times. The format in which the content is originally captured has considerable implications on network bandwidth requirements. See Table 1 on page 10 for details about format and associated file sizes.
- Storage Requirements—The content capture format also has implications on how much raw storage capacity is required in the data center for archiving the recorded content in the original (pre-production) format.
- Access Link speed—The link speed connecting the recording station to the network affects how quickly the recorded data can be transmitted to the packaging/transcoding Podcast Producer farm.
- Oversubscription ratios—Sufficient uplink capacity is required from the Access layer to the Distribution layer. This prevents delay in transmitting recorded content from the recording station to the Podcast Producer farm due to uplink oversubscription. Additionally, you should analyze the Distribution-to-Core and Core interconnections oversubscription ratios to ensure that sufficient capacity exists to transmit the recorded data within the target turnaround time.

Packaging Content

The following are the key factors to consider during the content packaging phase:

- Number of different transcoded formats required
- Time to transcode for desired formats
- Storage required for original and transcoded content

It is important to consider the Podcast Producer system requirements, although it is outside the scope of this paper to provide details about the Podcast Producer transcoding environment. For more information about the Podcast Producer system, see the following Apple web site:
Distributing and Staging Content

The following are the key factors to consider during the content positioning phase:

- Location of the content (onsite portal or external data center)
- If content is published locally, available storage at the on-site portal
- If content is published at an external data center, available bandwidth to the external data center
- Format (audio only, video, and so forth) of transcoded content (and associated file sizes) to be prepositioned for download
- Number of transcoded podcasts to be prepositioned for download

When building a network to support content workflow to iTunes U, consider if the content is located within the institution data center or hosted off-site. Although iTunes U began as a hosted service, beginning in July 2007, iTunes U now allows institutions to host their content elsewhere. This content is made available through iTunes U through RSS feeds.

An onsite portal has different system requirements than an implementation where the content is stored offsite. An onsite portal has internal availability and bandwidth considerations as well as storage requirement considerations for the content in both the original and transcoded formats.

If the content is positioned for download at the external data center, then connectivity to that center must be allocated to facilitate transfer from campus to data center within the target publication time.

The size and number of transcoded files needs to be evaluated relative to the speed of the Internet connection to the external data center location. If the campus Internet uplink becomes congested, this will adversely affect other applications. Contention for bandwidth may delay the turnaround time beyond an acceptable level. Refer to Table 1 on page 10 and Table 2 on page 13 for transcoded file sizes and the theoretical minimum transfer times based on typical link speeds.

Accessing and Downloading Content

Consider the following factors during the access and downloading phase:

- Location of the content (on-site portal or external data center)
- Available bandwidth from content staging site and users
- Size of the transcoded content being downloaded
- Number of podcasts being downloaded

Similar to the prepositioning phase, the downloading phase has different requirements if the content is staged at the external data center compared to staging the content locally on a portal in the local data center.

When the content is stored at an external data center, the primary concern is the Internet connection speed and how many podcasts can be simultaneously downloaded without unacceptable delays.

When the content is maintained internally at the university data center, the main concern is the bandwidth between the server staging the content and the users downloading the content. Access link, Access to Distribution oversubscription, Distribution-to-Core, and Core-to-Core interconnection capacity must be evaluated relative to the type and amount of content being downloaded.
Podcasting and its Impact on Campus Design

This section summarizes the impact of podcasting on the design on each layer of the campus network. It includes the following topics:

- Overview
- Access Layer
- Distribution Layer and Core-to-Core Interconnections
- Data Center
- Wide Area Network
- Internet
- Accessing and Downloading Content
- WLAN Considerations

**Overview**

When considering the impact of podcasting on the campus infrastructure, the application requirements of the specific podcasting solution are important. Adding content capture devices and implementing a process of recording and transmitting to a central location for packaging the content (workflow), can generate a considerable load on different layers and components of the network (see Figure 4 on page 9).

Oversubscription ratios may need to be adjusted and additional capacity added to different layers or components in the network, depending on the required turnaround time from completion of recording to the availability of content. The encoding method used for capturing and delivering the content also affects the impact on network resources and the recommended oversubscription ratios.

Figure 4 illustrates each resource in the network that is affected by creating, distributing, and downloading podcasts:

- Access Link Speed (10/10/1000)—Recording station connection speed affects uploading to Podcast Producer
- Access Uplink (GE, xGE, or 10GE)—Access to the Distribution Layer Uplink oversubscription also affects uploading to the Podcast Producer
- Distribution/Core Links (GE, xGE, or 10GE)—Distribution/Core oversubscription also affects uploading to the Podcast Producer
- WAN connections for satellite campuses affect scalability and performance at those locations
- Internet connection speed affects times for uploading transcoded files to an external data center
The red highlighted sections in Figure 4 illustrate the areas in the network that may require additional capacity.

**Access Layer**

The following are the main factors to consider when designing the Access layer:

- Format of the content to be captured
• Recording station Access layer link
• Access layer-to-Distribution layer uplink speed and oversubscription ratio

The first and most obvious concern is the Access link connecting the video recording enabled workstation in the classroom. This Access link is the first potential bottleneck. Depending on the encoding method, this link may need to handle as much as 13 gigabytes of data per hour. See Table 1 for a summary of encoding schemes and associated file sizes.

Table 1  Recording Formats, File Sizes, and Transfer Times Using Common Bandwidths

<table>
<thead>
<tr>
<th>Codec</th>
<th>File size</th>
<th>Link speed (megabits/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(bytes)</td>
<td>10</td>
</tr>
<tr>
<td>Raw Digital Video (DV)</td>
<td>13 gigabytes</td>
<td>3:30:07</td>
</tr>
<tr>
<td>h.264 (640 x 480)</td>
<td>1 gigabyte</td>
<td>0:14:19</td>
</tr>
<tr>
<td>AIFF/Wave</td>
<td>650 megabytes</td>
<td>0:8:23</td>
</tr>
<tr>
<td>Audio only (AAC)</td>
<td>54 megabytes</td>
<td>0:0:45</td>
</tr>
</tbody>
</table>

The Access layer link used by the content capturing station is a key link in the entire system. A 10/100/1000 Mb/s link is recommended and the video capture (Podcast Capture) devices should be equipped with a 1000 Mb/s (1 Gb/s) NIC (network interface card). This will help ensure that the initial content transfer is not delayed due to limited end-point connectivity.

Many organizations use Digital Video (DV) encoding at the recording station to capture the content with as much detail as possible. This allows the greatest flexibility for future use. However a single hour of raw digital video can result in 13 gigabytes transmitted over the network. If the Access layer link is a 10 Mb/s (megabits per second) link, the theoretical minimum time to transmit a one-gigabyte file is more than three hours. Even on a 100 Mb/s Access link, a 13 gigabyte file will take more than 18 minutes for transmission, and this is based on theoretical transfer times. The actual transmission times will be considerably longer due to transport layer overhead, congestion, and packet loss and retransmission.

A considerable amount of time could be required to transfer files from the recording station to a centrally located Podcast Producer farm if raw Digital Video format is chosen for the initial content capture format. Consider carefully the actual need to use DV at the edge and weigh that need against available network resources and end-to-end turnaround time requirements.

Another potential bottleneck in the network is the uplink from the Access layer switch to the Distribution layer. Depending on the required turnaround time from the completion of recording to availability of content for download, you need to be careful that the Access layer uplink to Distribution layer oversubscription ratio does not introduce a bottleneck for file transmission.

As illustrated in Figure 5 on page 11, the general rule of thumb used for typical enterprise traffic is to engineer for a 20:1 Access layer link to uplink oversubscription ratio. With a 20:1 oversubscription ratio, it is possible to deliver 20 times 13 gigabytes of data to the Access layer uplink. That is 260 gigabytes over a link that is typically 1 Gb/s (one gigabit per second). The theoretical minimum time for connecting 20 classrooms recording one hour of Digital Video (13 gigabytes per hour) is more than 37 minutes.
Given that this is a theoretical minimum, and the actual time is much longer, it is clear that oversubscription ratios need to be revisited to address loads that can be generated by rich media podcasting.

Many networks have been engineered with Access to Distribution layer oversubscription even higher than 20:1. It is common to use 48:1 oversubscription for a single 1RU fixed configuration switch or as much as 384:1 for a fully loaded modular chassis.

Uplink capacity and oversubscription should be carefully evaluated, considering the required end-to-end turnaround time and the number of video capture (Podcast Capture) devices connected to a single Access layer switch. An oversubscription ration of no more than 20:1 (uplink capacity to recording station connectivity) is recommended. Also, consider 10 Gb/s Ethernet uplinks from the Access to the Distribution layer to avoid congestion of the uplink.

**Distribution Layer and Core-to-Core Interconnections**

The primary concern at the Distribution and Core layers of the network is capacity and oversubscription affecting the end-to-end turnaround time. Carefully evaluate the capacity of the Distribution layer relative to expected system performance. No more than a 4:1 oversubscription ratio is recommended for this area of the network.

Additionally, 10 Gb/s Ethernet and possibly multiple 10 Gb/s Ethernet connections from the Distribution layer to the Core layers and Core interconnections within the network may be required to facilitate required end-to-end turnaround times in a large podcasting/rich media environment.

In a large campus, with video capture (Podcast Capture) distributed across many buildings, you should be careful that the Distribution-to-Core interconnections do not introduce a bottleneck into the end-to-end transmission time.
Data Center

The Data Center within a hierarchical network design is a specialized building block optimized to provide the service unique to this area of the network. The implementations specifics unique to deploying a datacenter can be found at the Solution Network Reference Design CCO web page (http://www.cisco.com/go/srnd) under the Data Center category.

It is important when planning for a podcasting environment that a comprehensive data center solution be implemented to ensure that the network facilitates the availability, resiliency, and performance requirements.

Data center connectivity requires special attention from an oversubscription perspective because the Podcast Producer farm and potentially a portal with the transcoded content will be located here. In a large podcasting environment, the links can become congested from the Core of the network into the data center building where the Podcast Producer (transcoding/packaging) farm is located. Care should be taken to provide sufficient link capacity from the Core into the data center distribution nodes and between those nodes and the Access layer containing the Podcast Producer machines.

Depending on the number of recording devices in the solution, this may require 1 Gb/s Access layer connections, 10 Gb/s Access-to-Distribution layer uplinks, and multiple 10 Gb/s Distribution layer-to-Core interconnections.

A 4:1 oversubscription ratio is the maximum that should be implemented in this area of the network. A 1:1 ratio may be required to achieve the end-to-end turnaround requirement in a large podcasting/rich media environment.

10/100/1000 Mb/s connectivity should be provided to the Podcast Producer farm machines and to any devices storing the transcoded content. 10 Gb/s Ethernet connectivity from the Access layer to the data center Distribution/Aggregation layer and multiple 10 Gb/s EtherChannel Distribution layer-to-Core connections to meet the target turnaround time should also be considered.

Other considerations that are important to the success of a podcasting solution that is housed at an internal data center include the following:

- Firewall Services
- Server Load Balancing
- Low Latency
- High bandwidth switching for xGRID communication between the Podcast Producer farm machines
- Storage Area Networking (SAN) to enable large disk farms that will be required for temporary, transcoded, and archival purposes

Wide Area Network

Wide area network (WAN) link capacity is also important when implementing a podcasting environment. The WAN connection is typically much slower than the campus connections. Care must be taken not to overwhelm the WAN and negatively affect other applications utilizing those links.

The WAN link capacity connecting the satellite campuses requires special attention. Very large files or many smaller files in a podcasting environment can exceed the capacity of a traditional WAN. As shown in Table 1 on page 10 and Table 2 on page 13, a podcasting environment can add considerable load to an existing network, and this can have a negative affect on existing applications. Additionally, the time required to transfer content over the WAN links should be considered because of the relatively low connectivity speeds. Traditional WAN links will use a large portion of the end-to-end turnaround time budget.
In a WAN environment, carefully consider the location of recording stations relative to Podcast Producer resources. For example, consider Podcast Producer resources at the satellite campus to reduce the load on WAN links.

Additionally, consider caching solutions, such as the Cisco Application and Content Networking System (ACNS) solution (http://www.cisco.com/en/US/products/sw/conntsw/ps491/). This can be used to stage transcoded content on the consuming side of the WAN before users begin downloading the content. This will further reduce the WAN bandwidth requirements of the overall podcasting solution.

You should calculate the theoretical minimum file transfer times to set realistic system expectations. It will take considerably longer to transmit recorded content to a centrally located Podcast Producer farm from the satellite campuses than from a campus location connected over Ethernet. Additionally, content consumers will experience longer wait times when they access the transcoded content over WAN links. For example, a 13 gigabyte DV recording that takes one minute 52 seconds to transmit over a 1 Gb/s campus interconnection would take more than 240 hours for transmission over a 128 Kb/s Frame Relay link!

Understanding the WAN capacity and minimum theoretical transmission times can help select encoding schemes and choose a location for the Podcast Producer devices. In the case of a satellite campus with a small WAN connection, it would make more sense to locate a transcoding and packaging (Podcast Producer) environment at the satellite campus and only transmit the transcoded content over the slower WAN interconnection.

**Internet**

You should evaluate your connection speed to the Internet when sizing a podcasting / iTunes U solution. The content may need to traverse your Internet connection in two directions. After the content is packaged and prepared for access in the data center by the Podcast Producer, it must be transferred to the data center that is hosting the content for download by end users. Again, you should calculate the minimum theoretical transfer time to set realistic expectations, which will depend on the number of courses transmitted simultaneously from the Podcast Producer systems to the external data center.

For example, one hour of content transcoded using h.264 (640 x 480) is approximately one gigabyte. If 20 courses are transcoded to h.264 (640 x 480) and sent to an external data center, the Internet connection needs to support transmission of 20 gigabytes within the target turnaround time. 20 gigabytes can theoretically be transmitted over an OC-3 (155 Mb/s) link in about 18.5 minutes.

Table 2 lists common Internet connection speeds and the time required for transmitting files using common transcoding types.

<table>
<thead>
<tr>
<th>Codec</th>
<th>File size (bytes)</th>
<th>Link speed (megabits/second)</th>
<th>100</th>
<th>155 (OC-3)</th>
<th>622 (OC-12)</th>
<th>1000 (GE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>h.264 (640 x 480)</td>
<td>20 gigabytes</td>
<td></td>
<td>0:28:38</td>
<td>0:18:25</td>
<td>0:04:36</td>
<td>0:02:52</td>
</tr>
<tr>
<td>AIFF/Wave</td>
<td>12 gigabytes</td>
<td></td>
<td>0:17:11</td>
<td>0:11:03</td>
<td>0:2:46</td>
<td>0:0:10</td>
</tr>
<tr>
<td>Audio only (AAC)</td>
<td>648 megabytes</td>
<td></td>
<td>0:0:54</td>
<td>0:0:35</td>
<td>0:0:14</td>
<td>0:0:01</td>
</tr>
</tbody>
</table>
As the system grows, you should monitor the transcoded file sizes, the number of sessions being loaded to the external data center facility, and ensure that the Internet connection speed is adequate to meet the target turnaround time.

**Accessing and Downloading Content**

You also need to consider the effect on the network infrastructure caused by users downloading the content. The load and utilization depends on the type of encoding used, whether the content is accessed from the external data center or from an internal portal, and on the number of users accessing the content network.

Two considerations are most important when evaluating the impact of a podcasting solution on the University’s Internet connection.

The first is the outbound capacity of the Internet connection and the load that may be generated as content is uploaded to the external data center. Carefully consider the number of podcasts, the format of the podcasts (audio or video), and the bandwidth required to meet the end-to-end turnaround time expectations. [Table 1 on page 10](#) and [Table 2 on page 13](#) can be used to determine the bandwidth that individual podcasts will use and how long it will take to transmit files over typical Internet connections.

Also, consider the impact that podcasting will have on other users and applications using the shared Internet resource. Because podcasting can add a considerable load, additional capacity may be required as the podcasting environment grows.

The second main consideration is access of the content by campus users. Considerable load can be placed on the university Internet connection in the downstream direction. Again, this load will vary based on the type of content (video or audio) and the number of users simultaneously downloading the content. In a large podcasting environment considerable load can be placed on the Internet connection when many users attempt to access the content at the same time. This load can adversely effect other applications using the shared campus Internet connection. Use [Table 1](#) and [Table 2](#) to estimate the potential load and evaluate the capacity of your Internet connections to handle the expected loads within acceptable download times. Additional capacity may be required to meet user expectations.
The red highlighted areas in Figure 6 illustrate the following major areas of concern:

- **WLAN**—Sufficient access point (AP) density is required to provide capacity for content downloads
- **Network oversubscription**—The same concerns exist for downloading content that affect uploading content. The typical 20:1 or 4:1 oversubscription ratios may be problematic.
• WAN connections for satellite campuses affect usability at those locations
• Internet connection speed affects how quickly content can be downloaded from the external data center

When content is located on a portal in the campus data center, the concerns that apply to the servers staging the packaged content are similar to those that apply to Access layer connectivity for the recording stations.

The link speed connecting the portal to the network must be sufficient to transmit the requested content or it may limit the overall performance of the entire system. Also, you need to analyze Access layer-to-data center Distribution layer uplink capacity and oversubscription ratios to ensure that the expected load can be transmitted within target turnaround times.

Finally, you should evaluate the data center Distribution-to-Core connections and oversubscription ratios to ensure that the capacity can meet expected loads and user expectations.

In the same way, you should evaluate Core-to-Core, Core-to-Distribution, and Distribution-to-Access layer interconnections and oversubscription ratios along the path from the data center to the end user. You should consider the expected number of simultaneous downloads and the size of the transcoded files to make sure the bandwidth can meet expected loads and required download times.

For example, if content is transcoded using a PC-usable video format (H.264 640x480), a one-hour lecture results in a one gigabyte file. If 20 courses are recorded and each course has 40 students accessing the content immediately when it becomes available, there can be 800 simultaneous one gigabyte downloads. If the system staging the content is connected to the network over a 1 Gb/s connection, the theoretical minimum time required to transmit the entire 800 gigabytes of data is one hour 54 minutes which might result in an unacceptable user experience. Also, in reality, the transfer time will be much longer due to transmission protocol overhead, congestion, packet loss, retransmission, and so forth.

When staging the content at an external data center, you should still consider the points of aggregation and potential bottlenecks from the Internet connection to the users downloading the content. The Internet connection is the first connection to analyze for sufficient capacity.

Using the same example as for locally staged content, 800 gigabytes of content could be simultaneously downloaded over the Internet connection. The theoretical minimum time required to transfer that much data is more than 12 hours over an OC-3 (155 Mb/s) or three hours over an OC12 (622 Mb/s). Even over a 1 Gb/s Ethernet connection, 800 megabytes of data would require nearly two hours to transfer. Remember also that these are theoretical limits based on the math calculations. Real-world transmission times are longer due to transmission protocol overhead, inefficiencies, packet loss due to congestion, retransmission and so forth.

The Internet connection is clearly the limiting factor in a podcasting environment where the content is housed in an external data center. However, the internal infrastructure should still be evaluated to identify potential bottlenecks where link speeds and oversubscription ratios could reduce overall turnaround times. As traffic traverses the campus network from the Internet towards the Access layer, pay the most attention to points of aggregation. The Access layer-to-Distribution layer link is a potential bottleneck because a 20:1 or higher oversubscription ratio is not unusual. You should consider providing additional capacity, depending on the maximum concurrent number and the file sizes of content downloads.

**WLAN Considerations**

A podcasting environment can provide unique challenges to the wireless local area network (WLAN) environment. You should consider the loads that can be placed on the WLAN when many users simultaneously access podcasting content.
As illustrated in Figure 6 on page 15, many users typically access content over the WLAN. You should consider the number of users, the rate of use, and the type of content when evaluating WLAN capacity. You should consider the basic properties of your WLAN implementation to determine the effect of implement a podcasting environment. WLAN is a shared medium, which means that the density of devices attached to the WLAN environment affects usability. Download times increase when many users compete to download files at the same time.

You need a structured WLAN environment with sufficient density of access points (APs) to provide the capacity to meet download speed expectations without adversely affecting other WLAN users. To deliver sufficient capacity, follow the guidelines provided in the Enterprise Mobility Design Guide (3.0). Following established guidelines will successfully address the capacity and density requirements when a significant podcasting solution is introduced into an existing network.

It is beyond the scope of this document to describe the detailed design recommendations for an Enterprise WLAN implementation. For specific recommendations, refer to the Enterprise Mobility Design Guide (3.0) at the following URL:


You can also access this document using the Mobility link at the following website:

http://www.cisco.com/go/srnd

The Enterprise Mobility Design Guide provides detailed design recommendations that address high-density, high-bandwidth requirements such as those in a podcasting (rich media) environment.
Appendix A: Bandwidth Calculations

The following are the values used as the basis for the calculations shown in Table 1:

- 1 megabyte = 8,388,608 bits
- 1 gigabyte = 8,589,934,592 bits

### Table 1  Bandwidth Calculations

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Table 1    Bandwidth Calculations

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### Table 1  Bandwidth Calculations

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