This white paper has been deprecated.

For the most up to date information, please refer to the Citrix Virtual Desktop Handbook.

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Desktops and
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XenDesktop -
Printing Planning Guide
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Overview

Printing is a very important aspect of every Citrix infrastructure, which is not well understood and a common cause of issues. Citrix XenApp and XenDesktop offer a variety of features to enable administrators to successfully integrate printing in almost every scenario. Choosing the most appropriate printing configuration for your organization helps to simplify administration and improve the user experience. In order to successfully design a printing infrastructure it is vital to understand the available technologies as well as their benefits and limitations.

This planning guide is intended to be a guideline during the printing strategy decision process, but it cannot provide turnkey solutions that fit for every scenario due to the complexities of each organization’s environment and user requirements.

The following tools and knowledge base articles can help planning or troubleshooting a printing infrastructure:

- eDocs – [Introduction to Windows Printing Concepts](#)
- [How printing works in Windows 7](#)
- [Printer Connectivity Technical Overview](#)
- [Printing – Architecture and Driver Support](#)
- [High Availability – Print Settings for a Clustered Print Server](#)
- [Common Microsoft and Windows Printing Terms defined](#)
- [Citrix Tools - StressPrinters](#) (Printer Driver testing tool)
- [Citrix Tools - Print Detective](#) (Printer Driver Troubleshooting)
Guidelines

In a XenApp or XenDesktop environment, all printing is initiated (by the user) on the server or virtual desktop. However, print jobs are not always sent directly from the server to the printing device. Instead, the print jobs can be redirected through the client device or a Windows print server.

Because there is no persistent workspace for users in XenApp or a shared virtual desktop (when a session ends, the user’s workspace is deleted), all settings need to be rebuilt at the beginning of each session. As a result, each time a user starts a new session, XenApp / XenDesktop must provision (recreate or restore) the printers available in a session.

It is possible to customize how XenApp / XenDesktop performs these tasks by configuring options for printer provisioning, print job routing, printer property retention, and driver management. Settings for these options can affect the performance of printing in an environment and the user experience. Within this chapter the printing related design decisions and respective technical information will be discussed.

Creating Printers

For a computer to process a print command, it needs both the required printer object and a printer driver. Because user sessions in a Citrix environment are hosted in a virtual workspace instead of locally on the workstation, printers and their drivers don’t have to be stored on the local computer. Instead, they are created or restored at logon or reconnect of the user on the virtual desktop. The process by which XenApp/XenDesktop makes printers available in a session is known as provisioning.

Printer provisioning can be controlled by the administrator. The specific configuration affects what printers are available to users within a session, and the performance of the printers. There are two types of printer provisioning:

- **Static.** Server local printers are provisioned only once, when you connect them to the farm server. After that, they are always created in sessions with the same properties and do not vary according to policies. This is typically used in small environments.

- **Dynamic.** The printers that are available in a session are determined as the session is initiated. As a result, they can vary according to changes in policy, user location, or network (provided they are reflected in policy). When printers are provisioned dynamically, the printers that appear in a session are not predetermined and stored. Rather, the printers are assembled, based on policies, as the session is initiated. This process is also called Auto-creation.

Because provisioning static printers is relatively simple, this topic focuses on provisioning printers dynamically.
Auto-Creating Client Printers

At the start of a user session, XenApp/XenDesktop auto-creates all printers available on the client device by default. Hereby locally attached printers (i.e. USB) as well as network-based printers (i.e. via print server) can be connected. This process is also referred to as local printer mapping. The Citrix policy setting “Auto-create client printers” enables administrators to control what types of printers are provisioned to users or prevent auto-creation entirely. Please note that users can connect client printers manually (if not explicitly prohibited by policy) from within the session as needed.

**Decision:** Which client printers should be auto-created in a user session?

**Recommendation:** In environments with a large number of printers per user, Citrix recommends to auto-create only one default printer. Auto-creating a smaller number of printers creates less overhead on the server / virtual desktop resources (memory / CPU) and can reduce user logon times. However, in environments where users with limited computer skills need to print to a wide variety of local printing devices, auto-creating all client printers will improve user experience and can reduce support calls.

Auto-Creating Session Printers

In addition or as an alternative to enumerating and mapping all network-based printers connected on a client device, XenApp and XenDesktop enables administrators to specify which network printers should be created within each session. This process can be controlled by means of the “Session Printers” policy. Network printers created with the Session Printers setting can vary according to where the session was initiated by filtering on objects such as subnets. This feature enables administrators to control the assignment of network printers so that the most appropriate printer is presented to the user, based on the location of the client device (also known as Proximity Printing).

The Proximity Printing solution is enabled through the Citrix policy settings “Session Printers” and “Default Printer” in conjunction with a policy filter based on a geographic indicator (i.e. IP address, client name, etc.).

**Decision:** When should Session Printers be used instead of auto-creating all client network printers?

**Recommendation:** Session Printers are an optimal configuration for scenarios where:

- Users roam between locations using the same client device (i.e. laptop)
- Thin Clients are used, which do not have the ability to connect to network based-printers directly
Print job routing

In a XenApp/XenDesktop environment print jobs can take two paths to a printing device: through the client or through a network print server. Which path is chosen by default depends on the kind of printer used:

- **Locally attached printers.** XenApp/XenDesktop routes jobs to locally attached printers from the server, through the client, and then to the print device. The ICA protocol compresses the print job traffic. When a printing device is attached locally to the client device, print jobs must be routed through the client.

![Diagram showing print job routing through a client](image1)

- **Network-based printers.** By default, all print jobs destined for network printers route from the server, across the network, and directly to the print server. However, if the XenApp server or the virtual desktop and the print server are on different domains (without trusts), the native printer driver is not available on the virtual desktop or XenApp server or direct network communication is not possible, print jobs are automatically routed through the client.

![Diagram showing print job routing through a client](image2)
This fallback behavior, which can also be modified by means of the “Direct connections to print servers” policy, can cause significant network overhead if not configured correctly. In a scenario with a data center based print server where print traffic for a network-based printer needs to be routed through the client, a print job may traverse the WAN three times.

Routing jobs through a network print server is ideal for fast local networks, but is not optimal for WANs. The spooling of print jobs using the network printing pathway method uses more bandwidth than using the client pathway; many packets are exchanged between the host server / virtual desktop and the print server. Consequently, users might experience latency while the print jobs are spooling over the WAN. Also, the print job traffic from the server / virtual desktop to the print server is not compressed and is treated as regular network traffic. When printing jobs cross a network with limited bandwidth, Citrix recommends routing jobs through the client device so that the ICA protocol compresses the jobs and enables the administrator to limit the maximum consumable bandwidth. If this is not possible, for example when a Thin Client without printing capabilities is used, Quality of Service should be configured in order to prioritize ICA/HDX traffic and ensure a good in-session user experience.

The following diagram visualizes the design decision tree related to print job routing:
Citrix Universal Printer

In the case where it is not desired to auto-create a large number of client printers at the beginning of each session, but connecting the default printer only is not an option due to limited flexibility, the Citrix Universal Printer should be considered.

The Citrix Universal Printer is a generic printer created at the beginning of sessions that is not tied to a printing device. Therefore it is not required to enumerate the available client printers during logon, which can greatly reduce resource usage and decrease user logon times. The Universal Printer can be used with almost any client-side printing device. Note that the Universal Printer leverages the Citrix Universal Print Driver, which is compatible with Windows end-points only. Please refer to section “Universal Printer Driver” within this document for further information.

Further information about the Citrix Universal Printer can be found in CTX106812 - The Citrix Universal Printer Explained.

Decision: When should the Universal Printer be used?

Recommendation: The Universal Printer is a good option for scenarios with the following requirements / pre-requisites:

- User logon performance is a priority and the “Start this application without waiting for client printers” is not an option, due to application compatibility.

- Users accept that all print outs will be sent to the local default printer by default. Alternatively a preview of the print out can be shown on the local client, where a different printer can be selected.
Managing Printer Drivers

In order to print on a print device it is required to install the respective printer driver. If the print device is changed a new driver or an updated version of the driver needs to be installed. In large organizations with hundreds of printers, managing printer drivers can become an intensive management task. Within this section technologies will be discussed, which can help to simplify this task and to ensure a resilient environment.

Automatic installation of printer drivers

When connecting a printer within a user session (auto-creating or manually), XenApp / XenDesktop will check if the required printer driver is installed on the XenApp server or virtual desktop. If this is not true the native printer driver will be installed automatically by default. In a hosted private desktop (XenDesktop) or hosted shared desktop (XenApp) scenario, where users can easily roam in between multiple end-points or locations (i.e. office and home office) the print devices used by a user may change very frequently. This could potentially cause hundreds of printer drivers to be installed on every hosted private or shared desktop, since users may be load balanced to a different hosted resource every time they connect. Within such scenario troubleshooting of printing problems and maintenance of existing drivers can be very complicated, since on every hosted resource the drivers and their installation order may differ.

Decision: Should the automatic installation of printer drivers be used?

Recommendation: The automatic installation of print drivers should be disabled to ensure consistency across the virtual desktops and XenApp servers to simplify support and troubleshooting. This can be achieved by means of Citrix and/or Microsoft Policies. Please note that the Windows Remote Desktop Services (RDS) include similar functionality. Therefore it is required to disable the automatic installation of printer drivers for RDP connections separately.

User-mode vs. Kernel-mode Drivers

Windows printer drivers are written in either user mode (also called version 3 drivers) or kernel mode (also called version 2 drivers). In Windows NT 4.0, drivers were moved into kernel mode to improve performance. However, when a kernel-mode driver fails, it can crash an entire system, whereas the failure of a user-mode driver causes only the current process to crash. Because of this difference, and because performance enhancements were made in Windows 2000 and Windows Server 2003, native drivers on Windows 2000 and later run in user mode. Windows Server 2003/2008 can still run kernel-mode drivers, although this is not recommended due to the impact on system stability.

Recommendation: For some legacy printers only kernel mode (type 2) drivers exist. In such scenarios administrators should verify if printer driver mapping, the Citrix Universal Printer Driver or the Universal Print Server can be leveraged in order to avoid installing the legacy driver on a XenApp server / virtual desktop. For further information, please refer to the respective sections within this document.
Printer Driver Mapping

In a scenario where the printer drivers installed on a XenApp server or virtual desktop are the same as on a client, but the drivers themselves are named differently (for example, “HP LaserJet 4L” versus “HP LaserJet 4”), XenApp / XenDesktop may not recognize the drivers are the same and users will have difficulty printing or printer auto-creation may fail. Overriding, or mapping, the printer driver name the client provides and substituting an equivalent driver on the server can resolve this issue. Mapping client printer drivers gives XenApp servers / virtual desktops access to client printers that have the same drivers as the server but different driver names.

**Decision:** When should printer driver mapping be used?

**Recommendation:** In scenarios where the Citrix Universal Printer Driver is not an option, mapping printer drivers can help to minimize the amount of drivers installed on a XenApp server or virtual desktop, which is a best practice. Furthermore it provides a workaround for printer drivers, which are known to cause issues. When mapping printer drivers Citrix strongly recommends testing the behavior of the printers in detail, since some printer functionality may only be available with a specific driver resulting in different print formatting.

Printer Driver Replication (XenApp only)

As outlined earlier it is vital to maintain a consistent set of drivers across all servers within a farm in order to simplify support and maintenance of the environment and to ensure a consistent user experience. XenApp includes a printer driver replication feature, which enables administrators to define a template server and deploy installed printer drivers in an automated manner to other systems within the same farm. Further information can be found in CTX126125 - [How to Replicate Print Drivers with PowerShell in XenApp 6.x](https://support.citrix.com/article/CTX126125).

**Decision:** When should the printer driver replication feature be used?

**Recommendation:** The printer driver replication feature can be a good option for small environments without any image management or software deployment solution. For large infrastructures it is recommended to leverage a centralized image management solution, such as Citrix Provisioning Services instead. These solutions enable administrators to perform maintenance tasks (i.e. installing a new printer driver) in a single location and deploy these changes or an updated version of the image to hundreds of systems with just a single click. In addition these solutions also allow a fast rollback of changes in case of unforeseen circumstances.
Citrix Universal Printer Driver

In order to simplify printing in XenApp / XenDesktop environments, Citrix has developed the Citrix Universal Printer Driver (UPD). The UPD is a device independent print driver, which has been designed to allow printing on any printer. Consequently, it simplifies administration by reducing the number of drivers required.

The Citrix UPD consists of two components:

- **Server component**: On a XenApp server or a XenDesktop based virtual desktop, the Citrix Universal Printer driver is installed as part of the XenApp / XenDesktop VDA installation. When a print job is initiated this driver records the output of the application and sends it, without any modification, to the end-point device of the user via the ICA/HDX connection.

- **Client Component**: The client component of the Citrix UPD is installed as part of the Citrix Receiver installation. It fetches the incoming print stream for the XenApp server / virtual desktop and forwards it to the local printing sub-system were the print job is rendered using the device specific printer driver.

Because of this architecture the Citrix UPD supports any print device, any advanced printer functionality (i.e. stapling, sorting) and does not limit resolution or color depth.

The diagram below illustrates the Citrix UPD components and a typical workflow for a printer locally attached to the end-point.

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Standard Win32/64 applications will format the application output, which is recorded in step one and replayed in step 3, in Enhanced Metafile format (EMF). Applications based on the new Windows Presentation Foundation (WPF) will format the output in XML Paper Specification (XPS). The advantages of XPS are a better print performance and a true “what-you-see-is-what-you-get” experience, when compared to a traditional environment without the Citrix UPD. In order to get all benefits of XPS, it is necessary to use a WPF application, a XPS driver and ideally
but optionally a XPS enabled printer. In case one of the components does not support XPS (i.e. a “traditional” printer is used) a conversion is required as outlined within the diagram below.

A conversion can also be used to get some of the XPS benefits for standard Win32/64 applications.

The matrix below describes the benefits of either combination.

<table>
<thead>
<tr>
<th>Path</th>
<th>Quality</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legacy path (EMF only)</td>
<td><strong>Baseline</strong> widely used today</td>
<td><strong>Baseline</strong> widely used today</td>
</tr>
<tr>
<td>GDI to XPS Conversion</td>
<td><strong>Good</strong>: Optimization for transparencies and gradients</td>
<td><strong>Better</strong>: Graphics optimizations and font subsets lead to smaller spool file size</td>
</tr>
<tr>
<td>XPS to GDI Conversion</td>
<td><strong>Better</strong>: Flattening filters applied to improve quality when converted to GDI</td>
<td><strong>Good</strong>: Intelligent flattening reduces rasterization</td>
</tr>
<tr>
<td>Fully native XPS</td>
<td><strong>Best</strong>: Transparencies and gradients contain native attributes for direct consumption</td>
<td><strong>Best</strong>: Native graphic attributes, resource management, and spool file support lead to the highest performance</td>
</tr>
</tbody>
</table>

Both EMF as well as XPS print streams are supported by the Citrix Universal Printer Driver. By default the EMF version of the Citrix UPD is used. This behavior can be controlled by the “Universal Driver Preference” policy.
Due to its architecture and the way it integrates with the Windows Print Sub-System the EMF/XPS Citrix Universal Drivers are compatible with Windows 32/64-Bit based end-points only. For non-Windows clients XenApp and XenDesktop feature the “HP Color LaserJet 2800 Series PS” driver. This driver is installed along with the UPD drivers and provides basic printing functionality for a wide range of print devices. In contrast to the EMF/XPS UPD this driver does not support advanced printer functions and limits the resolution of printouts to 600dpi.

**Decision:** When to use the Citrix Universal Printer Driver?

**Recommendation:** It is Citrix Best Practice to keep the number of print drivers installed on a XenApp server / XenDesktop virtual desktop to a minimum to help reduce management and potential stability issues. Therefore the Citrix Universal Printer Driver should be used whenever possible to reduce the number of print drivers required.

**Decision:** EMF Universal Driver vs. XPS Universal Driver

**Recommendation:** Although native XPS outperforms native EMF, this is not true for the Citrix Universal Printer Drivers. In this case the Citrix EMF Universal Printer Driver is superior to its XPS pendant, because of advanced print stream optimization algorithms, which are not available for XPS at this point in time. Furthermore the print out of print jobs using the EMF UPD will be started as soon as the first page has been transferred to the client. When using the XPS UPD the print out will be delayed until the full print job has been transferred.

Therefore it is recommended to leverage the Citrix EMF Universal Printer Driver whenever possible.
Citrix Universal Print Server

The Citrix Universal Print Server (UPServer) extends XenApp and XenDesktop universal printing support to network printing. This feature eliminates the need to install numerous network printer drivers on XenApp and XenDesktop hosts, and enables more efficient network utilization. The new Citrix Universal printer driver supports direct network printing on Windows and non-Windows clients. The Universal Print Server feature comprises of the following components:

- **Client Component**: This component is installed on a XenApp server or XenDesktop virtual desktop. It receives the EMF or XPS based print stream from the Citrix UPD and forwards it to the print server. Both the print commands and print data are sent over the wire using their own respective ports. Defaults are TCP 8080 for the print commands and TCP 7229 for the print data.

- **Server Component**: The Citrix UPServer component needs to be installed on a Windows based print server. It retrieves the print data and forwards it to the respective printer by means of the Citrix UPServer Virtual Port Monitor.

The diagram below illustrates the Citrix UPServer components and a typical workflow for a network based printer.

All manually or automatically connected network printers will leverage the Citrix Universal Print Server automatically (auto-discover), when the server and client components have been installed and configured successfully. Please note that the “Universal Print Server enable” policy needs to be configured in order to use the UPServer feature. It is disabled by default. There are two
options to enable it: one with fallback to the Windows print provider and another with no fallback.

For further guidance, please refer to eDocs – Universal Print Server.

**Decision:** When to use the Citrix Universal Print Server?

**Recommendation:** The Citrix Universal Print Server is highly recommended for remote print server scenarios. Because the print job is transferred over the network in a compressed format, the utilization of the network is minimized and the user experience can be improved. Furthermore the Universal Print Server enables administrators to keep the number of print drivers installed on a XenApp server / XenDesktop virtual desktop to a minimum, since all network printers will leverage the Citrix Universal Printer Driver. This helps reducing management and potential stability issues.
Planning

When choosing the optimal printing strategy, it is important to understand the printing technologies discussed within this document and the requirements of the respective infrastructure. This section including the following diagram outline a sample customer scenario, in which we’ll follow the topics discussed earlier opting for the simplest and best performing solution while still meeting the requirements.
This scenario is characterized by three use cases:

- **A small overseas branch office** with just a few Windows workstations in which every user uses a directly attached “private” printer (**Branch A**)

- **A large branch office** in which Thin Clients as well as Windows based workstations are used. For increased efficiency the users of this branch share network based printers (one per floor). Windows based print servers, which are located within the branch, are used to manage the print queues (**Branch B**).

- **A home office** in which the user leverages a Mac OS based client with a directly attached printer to access the Citrix infrastructure of the company (**Home Office**).

In order to allow all users to print by keeping the complexity of the environment low and the management simple, the following print technologies are used:

- **Branch A.** Since all users work on Windows based workstations, auto-created client printers in conjunction with the Citrix Universal Printer Driver (UPD) will be used. Doing so has two benefits:
  
  - **Performance:** Since the print job is delivered via the ICA printing channel the print data can be compressed. This saves bandwidth, which is a very limited resource in many cases. To ensure a single user printing a large document cannot impact the session performance of other users, the maximum printing bandwidth has been configured using the appropriate Citrix policy. An alternative solution would be to leverage a **Multi-Stream ICA** connection, in which the print traffic is transferred within a separate low priority TCP connection. Since QoS is not implemented on the WAN connection to this small branch, Multi-Stream ICA was a viable option.

  - **Flexibility:** Many organizations have a defined list of printer models, which can be ordered if a new printer is required. Unfortunately not all managers follow these guidelines. Especially in small newly established offices in emerging markets, printers are often bought from local dealers when needed. By using the Citrix UPD all printers connected to a client can also be used from within a XenApp or virtual desktop session without integrating a new printer driver in the data center based systems.
- **Branch B.** Since all printers in branch B are network based and their queues are managed on a Windows Print server, using the Citrix Universal Print Server is the most efficient configuration. All printer drivers required are installed and managed on the print server by the local IT admin staff. Mapping the printers into the XenApp / virtual desktop session works as follows:

  - Windows based workstations: The local IT team helps users to connect the appropriate network-based printer on their Windows workstations. This enables users to print from locally installed applications. When the users connect to a XenApp server or a virtual desktop the printers configured locally are enumerated (auto-creation). Then XenApp / virtual desktop will connect directly to the Print Server as a direct network connection if possible. Since the Citrix Universal Print Server components have been installed and enabled, native printer drivers are not required and the users are able to print right away. If a driver is updated or a printer queue is modified no additional configuration is required in the data center.

  - Thin Clients: For Thin Client users printers have to be connected within the XenApp / virtual desktop session. In order to provide users with a simple-to-use environment, Session Printer policies will be configured. A single policy will be created per floor which connects the floor printer as the default printer. To ensure the correct printer is connected even if users roam between floors, the policies will be filtered based on the subnet or the name of the thin client (proximity printing). With this model printer driver maintenance can be done locally (according to the delegated admin model). If a printer queue needs to be modified or added, Citrix admins will need to modify the respective Session Printer policy within the XenApp / XenDesktop environment.

Since the network printing traffic will be sent outside the ICA virtual channel, Quality of Service (QoS) will be implemented. Inbound and outbound network traffic on ports TCP 1494 and TCP 2598 will be prioritized over all other network traffic. Doing will help to ensure that ICA/HDX user sessions are not be impacted by large print jobs.
- **Home Office.** The simplest approach to enable printing for home office users, who work on non-standard workstations and use non-managed print devices, is to use auto-creation in conjunction with the Citrix Universal Printer Driver. In this sample scenario the user has a MacOS based client, which is not compatible with the EMF/XPS based Universal Printer Drivers (please refer to the respective section within this document for more details). In this case the “HP Color LaserJet 2800 Series PS” driver will be used to map the locally attached printer. As outlined earlier this driver is limited to a resolution of 600dpi (color) and does not support advanced printer features, which is acceptable for most home office scenarios.

To summarize the configuration of this sample architecture:

- No printer drivers will be installed on the XenApp servers / virtual desktops
  - Only the Citrix UPD will be used and fallback to native printing / automatic installation of printer drivers will be disabled.

- A policy will be configured to auto-create all client printers, which applies to all users
  - The XenApp servers / virtual desktops will directly connect to the print servers. This is default behavior. Besides enabling the Universal Printer Server components, no additional configuration is required.

- A session printer policy will be configured for every floor of branch B, which is applied to all thin clients of the respective floor.

- QoS will be implemented for branch B to ensure excellent user experience.
### Product Versions

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<td>• Andy Baker – Architect</td>
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<td>• Daniel Feller – Lead Architect</td>
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<td>Thomas Berger – Architect</td>
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### About Citrix

Citrix Systems, Inc. (NASDAQ:CTXS) is a leading provider of virtual computing solutions that help companies deliver IT as an on-demand service. Founded in 1989, Citrix combines virtualization, networking, and cloud computing technologies into a full portfolio of products that enable virtual workstyles for users and virtual datacenters for IT. More than 230,000 organizations worldwide rely on Citrix to help them build simpler and more cost-effective IT environments. Citrix partners with over 10,000 companies in more than 100 countries. Annual revenue in 2011 was $2.20 billion.

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