

The Unofficial Guide to NDI®

By Paul W. Richards

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DEDICATION

This book is dedicated to the StreamGeeks who make video productions amazing with their boundless creative energy.

CONTENTS

Forward	i
1 What is NDI®?	Pg 1
2 A brief history of NDI®	Pg 6
3 What is IP video?	Pg 10
4 Popular NDI® solutions	Pg 13
5 NDI® at the StreamGeeks	Pg 37
5 What is a local area network?	Pg 45
6 Bandwidth considerations	Pg 55
7 The OBS example	Pg 69
8 The vMix example	Pg 75
9 Simplifying video with IP	Pg 81
10 Using NDI® video cameras	Pg 84
11 Graphics generation with NDI®	Pg 91
12 Wireless NDI® & smartphones	Pg 94
13 NDI® powered video displays	Pg 100
14 Studio Monitor	Pg 102
15 NDI® Screen Capture	Pg 111
16 NDI® Webcam Input	Pg 116
17 NDI® Remote	Pg 119
18 NDI® Bridge	Pg 121
19 NDI® Tally	Pg 125

THE UNOFFICIAL GUIDE TO NDI®

20	NDI® Audio Direct	Pg 129
21	NDI® Update Notes	Pg 131
22	NDI® Access Manager	Pg 136
23	Multicast	Pg 149
24	It's your turn	Pg 151

FORWARD

Every so often there is a shift in the way we live and work that seemingly brings the way we just do things to a halt and introduces a new path. This is what happened when we went from ethernet cables between computers to wireless (WiFi) connections ... which then enabled portable devices ... which gave rise to laptop computers ... and eventually modern cell phones ... which, for a large part of the world, has now changed the very computers we use today. More importantly, these devices have meant that humanity can share information, which means that doctors have ways to diagnose illnesses, buses and trains have better safety devices, cars have better systems managing their fuel efficiency and the list goes on and on.

We are at a point where the phone in your pocket has a high quality camera, screens and computers are everywhere, and everything is connected by networks that allow any device to talk to any other. There is a revolution that is going to change the whole way the world collaborates, how we work with others, present projects, and make purchases. This revolution is going to be fueled in part, by video, and it will make content easy to work with. We will look back at the traditional ways of producing video in the same way that we look at computers with slow internet connections. We believe that Network Device Interface (NDI®) is going to be part of the engine that makes that happen and this book is going to help tell you the story of why and how this revolution will start.



Michael Kornet

This is an exciting moment in time. It's been more than half a decade since NDI® was architected by Andrew Cross and both the magnitude of users we now have (it's in the hands of millions of people) and the rate of adoption that keeps accelerating is beyond our biggest dreams. Now, Paul has created the first definitive book on NDI® and in doing so will bring the benefits and understanding of this technology standard to a whole group of new content creators and storytellers.

Michael Kornet

Vice President Business Development, NDI

Paul was there with NDI® from the very early days and it has been one of those very lucky happenings when you find an organization like Haverford made up of people that you not only respect for their vision and accomplishments but truly just enjoy being around and working with.

When this protocol was created, the mission of NDI® was to grow IP Content as fast and wide as possible. This book in your hands helps make that possible and we could not be more thankful or excited about the shift to a new standard of IP Content built on NDI® that we are all witnessing. To be a

part of a technology shift like this comes around maybe once or twice in a career and so it is so fun to see and important to have NDI® brought to life in a way that anyone can understand and start playing with.



Dr. Andrew Cross

So, enjoy the magic of NDI® and IP Content. Welcome to a significant shift in the way content is created, distributed and consumed.

*Andrew Cross, Architect of NDI and President of Re&D,
Vixrt Group*

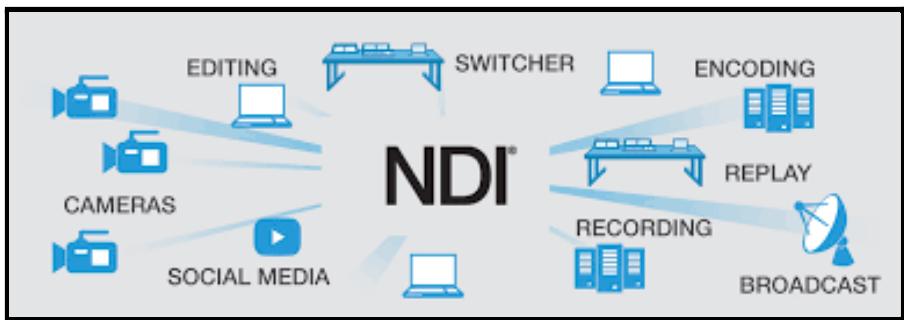
Chapter 1

WHAT IS NDI®?

Network Device Interface (NDI®) is a high quality, low latency IP video transmission standard that is popular for video production. NDI® is an easy way to connect live video sources between computers. The NDI® video connection standard was initially adopted by the live video production industry for use in software including Wirecast, vMix, LiveStream Studio, OBS (via a plugin), xSplit, and the NewTek TriCaster. Today, NDI® is used in a wide variety of video applications including broadcast, distance learning, and video communications. It's easy to use NDI® with almost any project that uses video on a computer since there are so many software and hardware integrations.

Most users of NDI® are looking for a new way of connecting video sources beyond standard High Definition Media Interface (HDMI) and Serial Digital Interface (SDI) cables. HDMI and SDI video cables have obvious limitations like cable distance and resolution. NDI® offers much greater flexibility compared to traditional video cables because it uses network connections that are already in place for most computer systems.

To get started, users can download free NDI® tools which are used to send and receive video over a standard Local Area Network (LAN). Over the years, NDI® tools have grown to include NDI® video viewing applications, screen capture software, virtual webcam inputs, remote camera controls, and KVM solutions. There are even apps for iOS and Android devices that can turn a smartphone into a camera or presentation tool using NDI®. NDI® tools allow anyone to get started using IP video and easily leapfrog old technologies that used to require expensive video capture cards and switchers.



Example of an NDI® ecosystem.

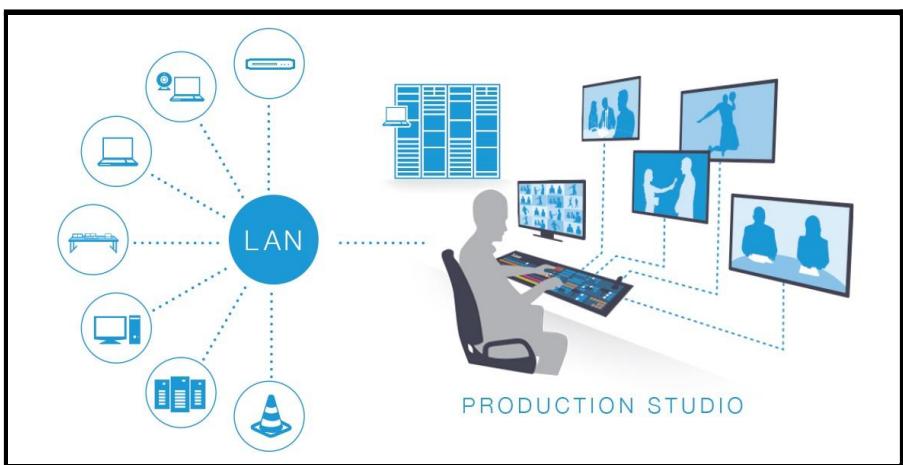
All NDI® compatible software and hardware becomes part of a larger ecosystem where all sources are visible and available to other computers on a network. In this way, NDI® video sources open up a new world of connectivity that is far beyond traditional point-to-point video cabling. While IP video is not a new concept, NDI® has brought ease of use and flexibility to the complex world of network video.

With thousands of developers using the royalty-free NDI® standard, video production professionals are able to find new and innovative ways to use the solution. At its core, NDI® makes the ability to quickly discover, send, and connect IP video sources incredibly easy and reliable. NDI® users will tell you that “it just works” which, in part, is due to the discovery system that allows software and hardware systems to easily find each other on a LAN.



NDI® High Efficiency Logo.

Over the years, NDI® has released new connectivity options such as NDI|HX® which stands for “High Efficiency.” NDI|HX® was announced in 2017 and provides additional flexibility for bandwidth control when sending video over a LAN. NDI|HX® has also made the use of NDI® video over WiFi and other bandwidth constrained networks possible. In 2020, NDI|HX®2 was announced with a slew of new improvements that optimize NDI®. With two NDI® video options available, NDI|HX® is known as the “High Efficiency” version and NDI® HB is known as the “High Bandwidth” option. Other important tools that you will learn about in this book include NDI® Studio Monitor, which allows users to quickly browse and control video sources on any Mac or PC computer, and NDI® Access Manager which provides security and network management for IT professionals.



NDI® in use with various software and hardware devices connected to the Local Area Network (LAN).

So how does NDI® actually work? NDI® requires a LAN, which is a network of computers connected with networking equipment. Networking equipment has become affordable and essential to modern communications. You likely have a network in your home or office already that's capable of using NDI®. Networking equipment has revolutionized the way that you can access the internet, communicate

with the world, and connect your computer to other software and hardware systems. NDI® is able to use standard networking equipment to allow you to send and receive video from various sources on your network. In an upcoming chapter, you will learn more about LANs and how you can use them to produce video with NDI®.

Some networking knowledge is required to start using NDI®. If you use Open Broadcaster Software (OBS), the world's most popular live video production software, you will find a free plugin available to add NDI®. It's simple to use, and allows you to start sharing the output of your OBS production on your network with another computer. If you use vMix, one of the most popular professional video production solutions, NDI® functionally is already built in. You can use a smartphone with the NDI® mobile app to get started right away. But NDI offers so much more. There are so many ways to use NDI® with thousands of software and hardware configurations.

NDI® is quickly changing the world of video. With the potential to eliminate the need for custom cabling, interfaces, capture cards, and additional hardware, NDI® provides a versatile solution for sharing, recording, displaying, and broadcasting video over standard ethernet networks. The NDI® protocol offers a new level of flexibility without compromising quality. This means high-quality, low-latency video over ethernet is now plug and play in most cases. With the latest versions of the NDI® protocol, it is possible to create and operate an entire video production workflow using a LAN and sources connected by WiFi, thanks to the latest highly efficient NDI|HX®.

NewTek announced the NDI® protocol for audio and video in 2015. NDI® can encode any audio and/or video source such as a camera, graphics package, screen capture, or pre-recorded video files and send them over a standard local area network (LAN). NDI® is not limited to using NewTek hardware and software. Any other NDI® enabled computer, device, or software on the same network can receive and decode the signal and view, record, and stream it, or use it in combination with other audio and video in a live or recorded production.

In simple terms, with NDI®, there is no longer a need to run SDI or HDMI cables to cameras and other devices as long as you can connect them to your LAN. Even better, you can access sources on the network from anywhere else on the network. NDI® can be efficiently routed to multiple locations while conserving bandwidth with easy to use tools for managing video on your network. Producers also have far more options for routing and sharing audio and video across a network. This new freedom has sparked a creative renaissance for live video productions where producers have new possibilities that used to be out of budget and far too complicated.

NDI® is a highly flexible protocol, and it is quickly being adopted by hardware and software vendors. Some devices come with NDI® pre-installed, and many software packages are ready to send or receive NDI® signals natively.

Key Takeaways:

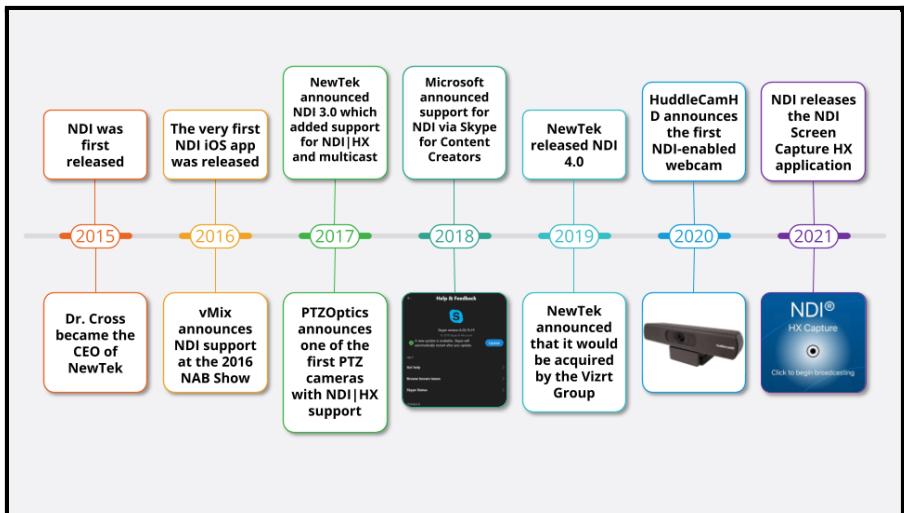
1. NDI® is an IP video standard that uses computers and networking equipment.
2. Some minimum requirements for computers are necessary to use NDI®.
3. Some minimum requirements for networking equipment are necessary to use NDI®.
4. While little networking knowledge is required to use NDI®, setting up a network to optimize NDI® requires networking experience.

Chapter 2

A BRIEF HISTORY OF NDI®

NDI® was first released in 2015, at the International Broadcast Conference (IBC) show in Amsterdam. Dr. Andrew Cross had been working on IP video technology as the chief technology officer at NewTek prior to the release. The predecessor to NDI® was called AirSend and it was used primarily as an IP video tool for NewTek TriCaster users. In 2015, Dr. Cross became the CEO of NewTek which marked a transition for the company toward the future of IP video. While other IP video standards existed at the time including SMPTE 2022 which was released in 2007, Dr. Cross and his team at NewTek were determined to create a new standard for IP video.

The very first demonstrations of NDI® were shown on a NewTek TriCaster. NewTek, which is now owned and operated by the Vizrt Group, is a Texas-based video production company which was started in 1985. The TriCaster is NewTek's flagship product, which offers live video switching, broadcast graphics, virtual sets, audio mixing, recording and much more. Ten years after its first release in 2005, the TriCaster became the world's first natively integrated NDI® video switcher.



Visual timeline of key moments in the evolution of NDI®.

Software and hardware integration announcements for NDI® kicked off in 2016 when vMix, a popular PC-based video switcher, released NDI® support at the National Association of Broadcasters (NAB) show. At this time, the NDI® Software Development Kit (SDK) was used by developers from around the world. Gallery Sienna, for example, released a desktop scan converter application for MacOS users along with an NDI® signal generator. The very first NDI® iOS app was also released in 2016.

Later in 2016, NewTek released NDI® 2.0 which included support for discovery across subnets. Also in 2016, Magewell, a major video capture and distribution company, announced seamless support for NDI® with its PCIe capture cards. In 2017, NewTek announced NDI® 3.0 which added support for NDI|HX® and multicast. NDI|HX® allowed PTZ camera manufacturers, such as PTZOptics and eventually, Sony to integrate NDI® directly into their camera models. NDI|HX® provides lower bandwidth NDI® video streams to maintain high quality and low latency video connectivity.

By 2018, Microsoft announced support for NDI® via Skype for Content Creators. Hundreds of software and hardware companies were now promoting their integrations for NDI® as an easy way to integrate with the growing ecosystem. Software solutions that supported NDI®

by 2019 included Avid, EVS, OBS (with a plugin), Wirecast, vMix, Livestream Studio, xSplit, TriCaster, MimoLive and many more. At this time, Magewell debuted its NDI® bridge software at the 2019 NAB Show.

In 2019, NewTek released NDI® 4.0 which included a slew of updates that made NDI® faster and more efficient. These enhancements came in part from hardware TCP acceleration. Throughout the history of NDI®, a free NDI® tool pack has been made available to the public. This tool kit includes NDI® Studio Monitor, NDI® VLC Plugin, NDI® Test Patterns, NDI® Screen Capture, NDI®|HX Driver, NDI® for Adobe® Creative Cloud®, NDI® Webcam Input, NDI® Access Manager, NDI® Import I/O for Adobe CC, and NDI® Screen Capture HX. These NDI® tools will be covered in more detail in an upcoming chapter.

In 2019, NewTek announced that it would be acquired by the Vizrt Group. Vizrt, which is short for “visual artist,” is a Norwegian company that creates content production, management, and distribution tools. After the acquisition, Vizrt separated NewTek and NDI® into separate companies. Dr. Cross accepted a position as the President of Global Research and Development at Vizrt and the NDI® community continues to grow.

In 2020, HuddleCamHD announced the world’s first NDI®-enabled webcam called the HuddleCamHD Pro IP. In 2021, NewTek released NDI® Screen Capture HX along with updates to the entire NDI® tool pack.

Since its introduction, NDI® has been updated with several new versions. The original NDI® was replaced by NDI® 2.0, NDI® 3.0 and so forth. Throughout this evolution new features based on customer requests have been added. NDI® 3.0, for example, added the important multicast feature you will learn about later in this book, the NDI|HX® protocol, and support for PTZ cameras. Multicast enables audiovisual content to be sent to multiple destinations simultaneously without significantly increasing the overall bandwidth used to send video separately using unicast. NDI|HX® is a more efficient, lower data rate codec. This upgrade helps to expand NDI® into situations

with more limited bandwidth. Support for PTZ cameras from specific manufacturers cleared the way for NDI® to become an end-to-end solution for video production. In addition to several performance improvements, NDI® 4.0 added support for NDI|HX2®, providing a truly native NDI® stream for many hardware products which increased reliability and reduced latency.

On June 2, 2021, NDI® released version 5.0. NDI® 5.0 builds upon the ability to record unlimited video sources for true multi-camera editing with frame accurate synchronization. NDI® 5.0 also introduced NDI® Bridge, a tool for transferring video over long distances without the need for 3rd party applications. NDI® Bridge allows multiple NDI® networks to gain connectivity from anywhere in the world. NDI® 5.0 also included NDI® Remote, a tool to connect individuals and receive their audio and video with the click of a link from any internet-connected device. NDI® Remote is now being used to connect live show interviews and camera sources from around the world.

New updates for NDI® are announced on a regular basis. You can follow ndi.tv/community for the latest news.

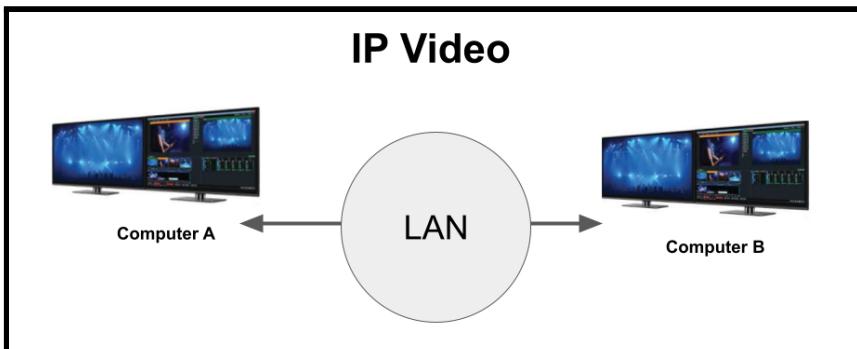
Key Takeaways:

1. NDI® has been in use for many years.
2. New applications and integrations are being announced for NDI® on a regular basis.
3. A community of software and hardware developers collaborate to create new solutions for the NDI® ecosystem.
4. New releases of NDI® help to make the entire system more efficient.

Chapter 3

WHAT IS IP VIDEO?

IP Video is a term used to describe video that is distributed on an IP network. The “IP” in IP Video stands for Internet Protocol, which is a set of standards for communicating over computer networks. IP Video devices can include cameras, hardware or software switchers, graphic workstations, and displays. NDI® is just one type of IP Video that has become a popular standard for live streaming and video production.



An IP video connection between two computers.

Advantages of IP Video

IP video offers many advantages over standard cable connection options. One benefit is scalability. As demands grow, adding additional cameras and other sources can become complicated when you are using traditional HDMI or SDI cabling. Hardware switchers can quickly run out of inputs, and many computers are limited on the number of capture cards or peripheral component interconnect express (PCIe) inputs that can be connected. With IP video, a single ethernet cable can handle a large number of sources, and there is no additional expense in terms of capture cards and hardware video switchers.

Note: Traditional HDMI and SDI sources can be connected to a computer and converted into NDI® video sources. This can be accomplished by using an NDI® encoder. Magewell for example offers a free NDI® Bridge which converts all video sources connected to Magewell hardware into NDI® outputs to accommodate modern IP video workflows.

Another advantage of IP video is the possibility of decentralized distribution. With a standard hardware switcher, all sources are routed to one location. With IP Video, sources are available anywhere on the network and can easily be sent to any other location on the network. This opens up a multitude of production and distribution possibilities.

IP Video also breaks the distance barrier of standard cabling options. While SDI connections can offer much greater lengths than more limited HDMI cables, they still face limits based on cable quality and capabilities. For example, an ethernet cable can be used for video, control capabilities and powering a device, whereas an SDI or HDMI cable can only handle audio and video. While there are limitations as to the length of individual ethernet cables (100 meters), these cables only need to make it to the nearest router or switch, not all the way from the source to the switcher.

Perhaps the most compelling advantage of IP video for many people is affordability. Most hardware video production solutions are expensive when compared to software alternatives. The prime example of this is capture card hardware. Before IP video, all video sources had to be run directly from the source to a capture device in order to be used with a video production solution. Today, NDI® removes the need for expensive capture cards and makes it possible to capture video directly through a computer's network interface.

IP Video Considerations

Before making the switch to an IP video solution such as NDI®, consider the challenges you may face with implementation. The biggest challenges may come to those who are comfortable with video standards but not with networking. A simple setup may be manageable for someone with no networking experience. However, more complex

configurations may require a higher level of understanding when it comes to networking or access to someone with the required knowledge. This book and online course, will help you gain a basic understanding of the networking skills necessary to manage an NDI® network for video production.

Key Takeaways:

1. NDI® is not the only IP video standard available today. However, it is one of the most popular IP video technologies used for live video production and communications.
2. IP video technology is helping to modernize video production.
3. IP video is helping make live video production more affordable.

Chapter 4

POPULAR NDI® SOLUTIONS

Once you have stepped into the NDI® ecosystem, you will find a growing number of hardware and software tools available to improve your production workflow and that offer new creative possibilities. Due to the nature of NDI®, there are many software tools that can do as much or more than previous hardware options. NDI® has always offered many resources to developers to add NDI® functionality to their software and hardware systems. The NDI® Software Development Kit (SDK) has helped many developers integrate NDI® into their products over the years since its release.

In this chapter, you will learn about the most popular tools and software solutions available for use with NDI®.

NDI® Tools	Streaming Software	Graphics Software
NDI® Studio Monitor, NDI® Bridge, NDI® Remote, NDI® Screen Capture, NDI® HX Driver, NDI® for Adobe® Creative Cloud®, NDI® Webcam Input, NDI® Access Manager, NDI® Import I/O for Adobe CC, NDI® Audio Direct, NDI® Screen Capture HX, NDI® Test Patterns	OBS, vMix, Wirecast, Livestream Studio, MimoLive, Wowza, xSplit, Manycam, NewTek Connect	ProPresenter EasyWorship Panamation Resolume Sportzcast

NDI® Hardware	Communications	Smartphone Apps
Magewell, Epiphan, LiveU, Teradek, PTZOptics, SONY, Panasonic, HuddleCamHD, NewTek, Cannon, Bluefish444, Tally-Lights LLC, Bird-Dog	Microsoft Teams, LiveToAir by Gnural Net, Skype	NDI® Camera NDI® Capture

The list above offers some of the most popular NDI® supported software and hardware solutions. Please note this is not a complete list.

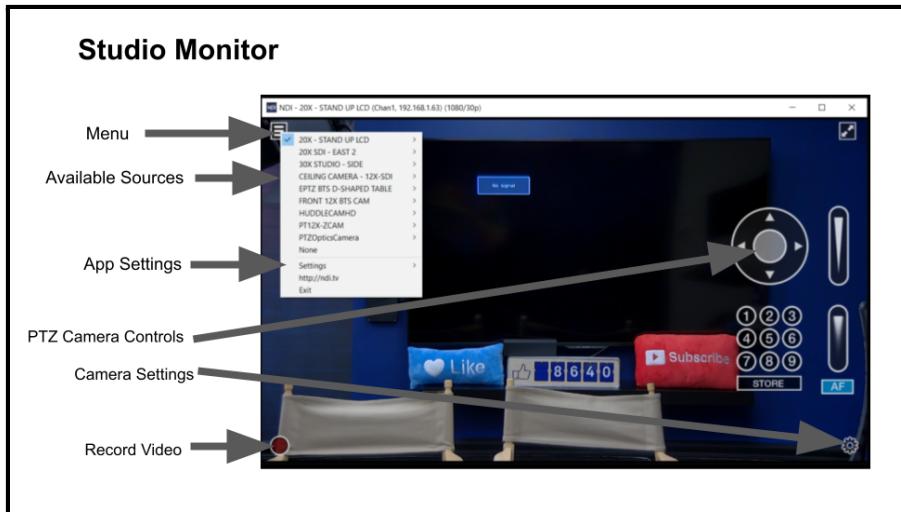


Free NDI® Tools

NDI® offers a free set of tools for you to get started. You can download these tools at <https://www.ndi.tv/tools/>. Below is a list of the most useful NDI® tools you can start using today.

Studio Monitor

Studio Monitor can be used on a Mac or PC computer to quickly display any NDI® video source available on your LAN. This application can quickly display all discoverable NDI® sources on your local area network. Studio Monitor has a long list of features which will be covered in an upcoming chapter. Most importantly, you can view any NDI® source and if the source is a PTZ camera, you can control the PTZ camera with an on screen control set.

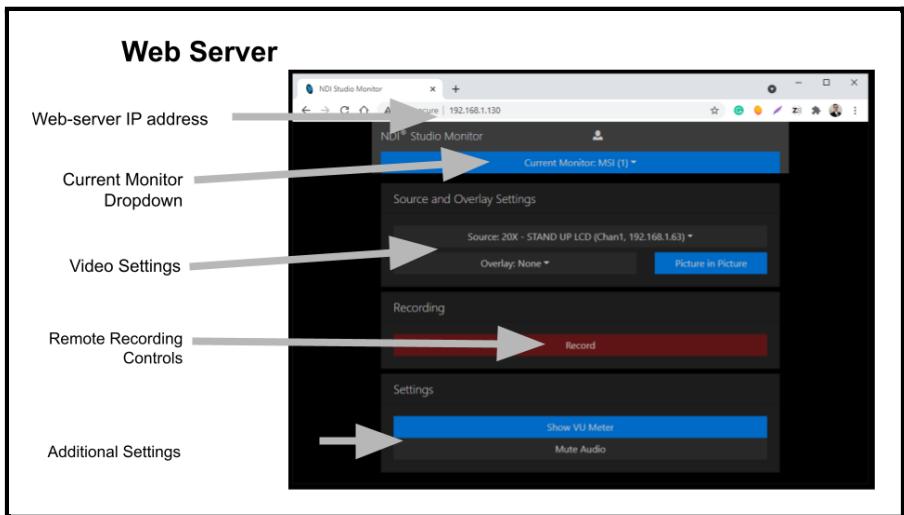


Studio Monitor connected to a PTZ camera will reveal PTZ camera controls.

NDI® Studio Monitor can also be controlled remotely by a web-server. The IP address for this web server can be found in the applications settings area. Once you enter this IP address into a web browser on the same LAN, you can access the control for Studio Monitor. This is particularly useful if you are using Studio Monitor to power a LCD screen that is remote to your current location. Applications include digital signage, video for overflow areas, and remote camera control applications. In this way, NDI® Studio Monitor can be used as a router to deliver customized NDI® video content to a number of displays on your network. Here is a summary of NDI® Studio Monitor benefits:

- Independently configurable video source, overlay, and audio per instance.
- Launch, distribute, and manage multiple instances from a single device.
- Support for control and configuration via compatible mobile devices.
- Comprehensive support for multi-monitor video wall and signage installations.
- Remote control of PTZ camera, recording, and configuration for applicable sources.

- Record NDI® files directly from multiple instances with NDI® Studio Monitor.
- Remote control via web server.
- NDI® output allows NDI® Studio Monitor to act as a router and server for delivery to multiple outboard displays.



Studio Monitor features a web server that can be used to control the application remotely.

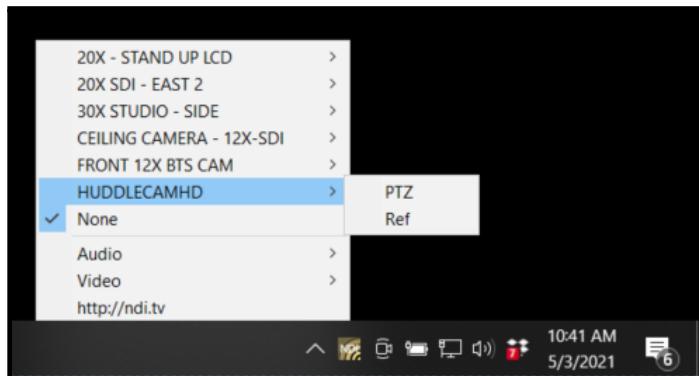
NDI® Webcam Input

The NDI® Webcam Input is a small utility which creates a virtual webcam source from any discoverable NDI® video source on your network. The NDI® virtual webcam is then usable with any software that uses the webcams. This mini application allows you to select an NDI® source that you would like to use as a webcam source in an application such as Zoom or GoToMeeting. Once selected, you can use any NDI® source on your network as a webcam in any application using the available “NewTek NDI®” virtual webcam selection.

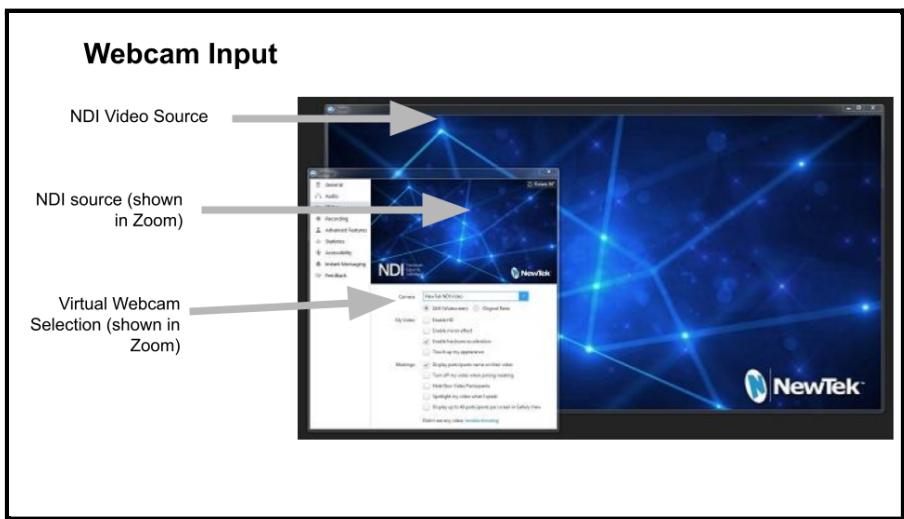
During the installation of NDI®, you can choose to have the NDI® Webcam Input “run at startup.” When the application is running it can be found in the system tray. You can click the application to open up a small menu of settings. It is here where you can choose

the NDI® video source you would like to make available as a virtual webcam.

The NDI® Webcam Input is compatible with Google Hangouts, GoToMeeting, Skype, Zoom, and more. It supports full frame rate video and audio up to 1080p and 4K UHD at 60 fps.



The Webcam Input application is found in the system tray.

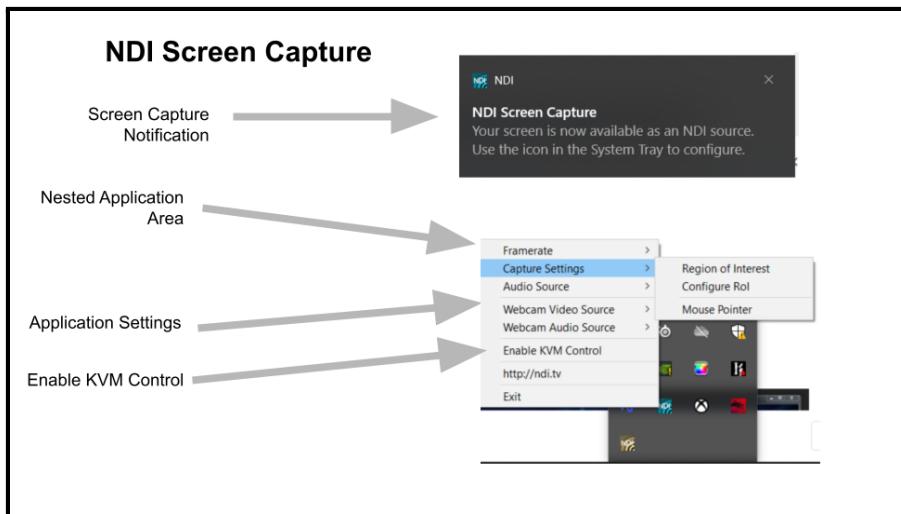


Webcam Input can be used with popular platforms like Zoom.

NDI® Screen Capture

NDI® Screen Capture can capture the screen of the computer it is installed on and make it available as an NDI® video source. NDI®

Screen Capture supports the capture of multiple monitors and it also includes the ability to capture a webcam. There are now two versions of NDI® Screen Capture -- the original version is called NDI® Screen capture, and a newer version is called NDI® Screen Capture HX. Both versions will be outlined in more detail in an upcoming chapter. The biggest difference is the encoding options which allow NDI | HX® Screen Capture to reduce bandwidth.

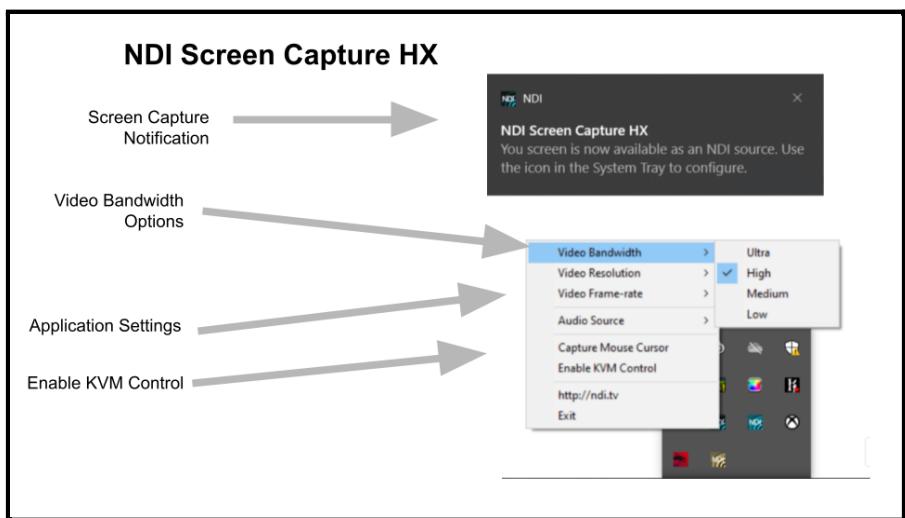


NDI® Screen Capture appears in the system tray.

Once NDI® Screen Capture is running on the computer you will receive a notification saying, “Your screen is now available as an NDI® source.” You will also see the NDI® Screen Capture icon in the System Tray. From here you can open up the application settings which include Framerate, Capture Settings, Audio Source, Webcam Video Source, Webcam Audio Source, and Enable KVM Control. Most of these features are self-explanatory, but the KVM control is an interesting feature you can use to take keyboard and mouse control for the computer remotely. Once enabled, the NDI® Studio Monitor application will allow you to control any computer remotely with the NDI® Screen Capture KVM Control feature enabled. Here are a few features the application enables:

- Generate multiple live video sources simultaneously with selectable audio.

- Support for multi-monitor capture, with independent output at up to 60Hz.
- Capture all of your system's desktops in real-time, at 60Hz and games at 120Hz or above with almost no CPU usage.
- KVM (keyboard, video, mouse) remote control of any workstation running Scan Converter from NDI® Studio Monitor.
- Consumes minimal system resources with no noticeable performance impact.

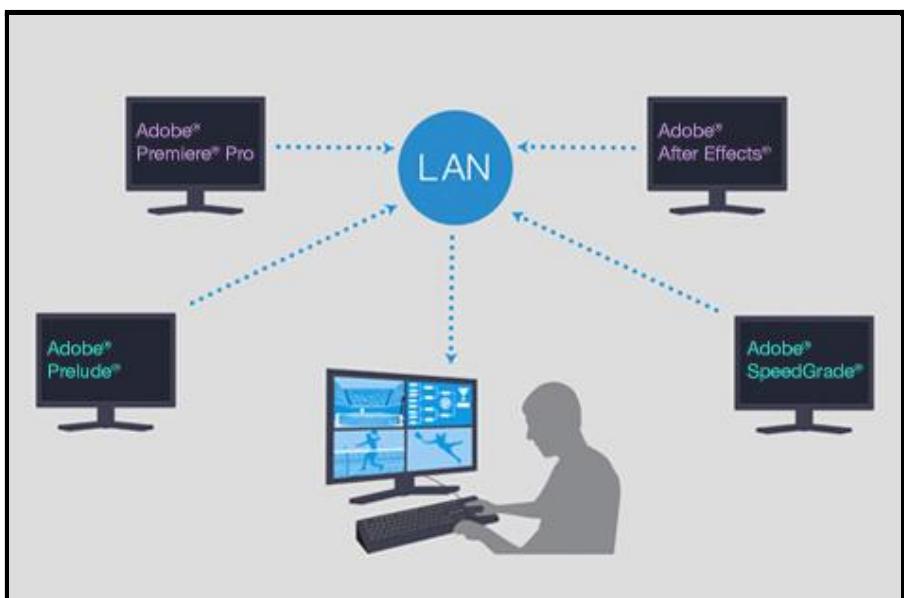


NDI® Screen Capture HX looks very similar to NDI® Screen Capture with a few new features.

NDI® Screen Capture HX

NDI® Screen Capture HX is the High Efficiency version of NDI® Screen Capture which features new levels of control for bandwidth optimization and Graphics Processor Unit (GPU) hardware acceleration. When the application is opened, a notification will let you know that your screen is being made available on the network as an NDI® source. NDI® Screen Capture HX includes four options for bandwidth levels. You can choose between Ultra, High, Medium, and Low. NDI® Screen Capture HX takes advantage of new graphics card video compression technology which can support resolutions up to 4K with surprisingly low bandwidth requirements. It allows:

- Full resolution screen capture up to 4K and above at frame-rates up to 120 Hz or higher
- End-to-end hardware acceleration including screen capture, color conversion, and video compression.
- High-quality dedicated encoding pipeline on NVIDIA hardware and full control over the video bitrate that enables superior image quality while using any network – including wireless networks.
- Low latency screen capture.
- Support for capturing audio from any sound device – input or output – that's fully synchronized with the video signal.
- Full remote Keyboard Video Mouse (KVM) controls, allowing remote control of keyboard, mouse, clipboard, and even touch from a remote machine.
- Full control over the video bandwidth, resolution, and frame-rate being used.

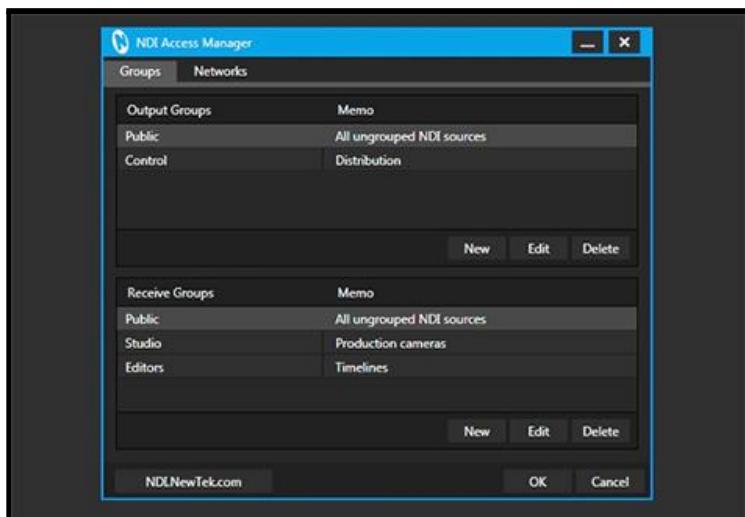


Adobe Creative Cloud products that work with NDI®.

NDI® for Adobe® Creative Cloud®

NDI® for Adobe Creative Cloud enables users to output NDI® video directly from Adobe products including After Effects and Premiere Pro. This allows video producers to quickly output video directly from the timeline of their projects for review and approval. These applications include Adobe Premiere Pro, Adobe Prelude, Adobe After Effects, and Adobe SpeedGrade. NDI® for Adobe Creative Cloud is:

- Compatible with Adobe After Effects® CC, Premiere® Pro CC, and more.
- Supports full-resolution, real-time video with audio, and transparency.
- Viewable from any NDI®-enabled receiving device anywhere on the network.



NDI® Access Manager set-up with multiple public and private groups.

NDI® Access Manager

NDI® Access Manager allows administrators to restrict access to NDI® video sources on their network. The application allows users to manage visibility and accessibility of NDI® sources to specific computers on a network. NDI® Access Manager can easily group

NDI® sources together to make them either public or privately discoverable. It also enables administrators to:

- Configure NDI® channels as public or private on the network.
- Group NDI® systems, devices, and applications to preference.
- Connect to and access NDI® channels on other networks via an IP address.
- Connect to and access NDI® channels on other networks via an IP address.
- Advanced controls allow preferences for Transmission Control Protocol (TCP) or User Datagram Protocol (UDP) connections, multicast operation, and optional discovery server support.

NDI® Audio Direct

NDI® Audio Direct is a tool designed to bring NDI® audio sources into Digital Audio Workstation (DAW) software. DAW software solutions are used to record, edit, and produce audio. The NDI® Audio Direct tool leverages two plugins that are designed to transport audio in and out of DAW software solutions. NDI® Audio Direct is compatible with any DAW that supports VST 3 or LV2 audio plug-ins.

NDI® VLC Plugin

VLC is a free open source video player. VLC's wide user adoption has led NDI® to support the system with a free plugin. The plugin allows NDI® video sources to be directly accessible with compatible VLC software without the need for transcoding.

- The plugin is compatible with existing and previous versions of VLC Media Player for Windows.
- It makes content accessible without transfer, transcoding, or direct connectivity.
- It supports encoding of multiple instances of the VLC Media Player simultaneously.
- It offers virtual PTZ control for the pan function and zoom control around VLC output.

NDI | HX® Driver

The NDI | HX® Driver is required to connect with certain NDI | HX® devices such as PTZ cameras or encoders. Newer devices that support NDIv4 or later will not require this driver.

- The NDI | HX® Driver is compatible with systems, devices, and applications supporting NDI®.
- High-efficiency transfer is optimized for limited bandwidth environments.
- It's suitable for WiFi, remote, and large-scale networks.

Video Production Software



Livestream Studio

Livestream Studio is a popular live streaming software solution that Vimeo offers. Livestream Studio supports NDI® inputs and outputs along with PTZ camera control support for NDI®-enabled cameras. Livestream Studio is a professional video product that was made popular by Livestream.com. Vimeo continues to support Livestream Studio and offers the product to customers using Vimeo's cloud services for premium live streaming.



MimoLive

MimoLive is a Mac-only live streaming software designed specifically to optimize video production capabilities on Mac OS hardware systems. MimoLive has become a favorite for Mac users who enjoy video resolutions up to 8K, plus simultaneous streaming to YouTube, Facebook, Twitch and many more destinations. MimoLive supports NDI® inputs and outputs, plus it also features support for PTZOptics PTZ camera controls over IP. This allows MimoLive to work seamlessly with PTZOptics NDI® camera models.



NewTek TriCaster

NewTek's flagship TriCaster video production switchers include what may be the most highly integrated NDI® functionality of any hardware switcher. The NewTek TriCaster mini, for example, is described as an "NDI® First" video switcher. Other TriCasters include the TC1 and the TriCaster 2 Elite.

NewTek Connect

NewTek is a video production equipment manufacturer owned by the Vizrt Group. NewTek Connect is a free software solution that simplifies your video workflow. You can quickly expand the number of sources available on your NDI® network by converting existing video sources into NDI® using NDI® Connect. The software is installed on the host computer and instantly accesses any camera or other device connected via a capture card over your local area network. You can

even enable the computer's webcam to add another source to your production.

Any signal sent or received by a compatible capture card (such as cards from AJA, Blackmagic, and others) can be made available across the network via NDI® for use in live production, recording, streaming, or display purposes. NewTek Connect is free, but it only features one channel of video. NewTek Connect Pro allows you to connect up to four channels of video.

NewTek Connect Pro

NewTek's Connect Pro expands upon the standard Connect software to turn a standard PC into a production workhorse that can bridge multiple conventional and IP-based formats. From standard video capture devices to IP cameras, webcams, media files, existing video streams, the software can handle all your sources and help you distribute them to multiple destinations.

Capture any input source on your local area network and send a signal as an output to hardware elsewhere on the network. Within the software, you can adjust the signal with the integrated Waveform and Vectorscope, independent color correction settings, and eight channels of configurable audio.

NewTek Connect Pro also adds another dimension to monitoring with the NDI® Connect Webserver. Just open a browser on any compatible device on your network and view up to 16 NDI® sources simultaneously with configurable layouts.



**Open Broadcaster
Software**

OBS (Open Broadcaster Software)

Open Broadcaster Software (OBS) is a free open source live video production software. Palakis, a software developer, released a plugin for OBS in 2017 which provides NDI® support in a variety of ways. The most common use for the plugin allows OBS users the ability to connect multiple OBS systems together. The plugin provides NDI® outputs, inputs, and a special filter to turn any OBS source or scene into an NDI® output. OBS is the world's most popular live streaming software partly because it is free and maintained by a world class group of open source developers.



vMix

Software video mixer vMix announced support for NDI® in 2016, years before many other paid video production software solutions. The product's lead developer, Martin Sinclair, has been an NDI® proponent since its release and continues to support the latest versions of NDI® as they are released. The way vMix supports NDI® inputs and outputs is that it allows users to turn all cameras into NDI® outputs. In fact, vMix can turn all cameras and all audio inputs into NDI® outputs. Those who are well-versed in streaming software industry trends are hard-pressed to find a better software-based video production solution with such detailed NDI® support.



Wirecast

Wirecast

Wirecast is a popular live streaming software available for both Mac and PC users. Wirecast announced support for NDI® inputs in 2017 which allows users to bring any NDI® source directly into Wirecast. Wirecast also added support for NDI® outputs which allows users to output NDI® sources from Wirecast.



Wowza

Wowza is known for its cloud-based live streaming products. Wowza's streaming engine is used to power live streaming and on-demand applications for almost any type of device. Wowza has partnered directly with NewTek to build NDI® into jointly developed encoding products.



xSplit

The popular live streaming and recording software xSplit is used by over 13 million people worldwide. It features NDI® input and output functionality which is ideal for creators, especially those in esports, who use the software to live stream and record videos.

Graphics Software



EasyWorship

EasyWorship is a presentation software that is designed to help worship leaders. EasyWorship supports NDI® inputs for bringing in video sources from other devices on the network. EasyWorship demonstrated its compatibility with PTZOptics NDI® cameras at the Worship Facilities Expo in 2018. EasyWorship also supports NDI® outputs to easily share the output of the software to other NDI®-enabled devices.



Panamation

Panamation is a live character graphics and paint tool available to make live annotations via NDI®. The product is designed to provide users with a simple interface to annotate on top of other NDI® video sources. As an NDI® output, the alpha channel video can be overlaid inside on top of other video sources.



ProPresenter

ProPresenter is a live production and presentation solution available from Renewed Vision. ProPresenter is popular for houses of worship among other productions that require live lyrics and presentations to be incorporated into a video format. ProPresenter supports NDI® outputs that allow you to easily connect to the Pro Presenter output from anywhere on a LAN.



Resolume

Resolume is a software for “VJs” or Visual DJs. Resolume supports NDI® inputs and outputs that allow the software to connect to other

computers on the network. Resolume is primarily used by musicians and entertainers in live performance environments.



Sportzcast

Sportzcast is a live scoreboard system that supports NDI®. Sportzcast devices can connect to an existing scoreboard and output the scores via NDI® video. In this way, a simple Sportzcast box can automate the graphics coming into an NDI® compatible video switcher. Because Sportzcast equipment can be placed in-line with existing scoreboard systems, the data can be added into NDI®-enabled video systems seamlessly.

NDI® Hardware Manufacturers



Magewell

Magewell is one of the world's top manufacturers of video capture devices and pioneered video capture for SDI, HDMI, and NDI® in many forms including the PCIe and USB formats. Magewell makes a variety of NDI® decode and encode solutions which provide the NDI® ecosystem with a multitude of product options. Magewell has also developed a software solution called the Magewell Bridge which can convert almost any Magewell product into an NDI® output.

HuddleCamHD

HuddleCamHD

HuddleCamHD is a video communications hardware manufacturer that specializes in plug and play devices. HuddleCamHD released the industry's first-ever NDI® webcam called the HuddleCamHD Pro IP. HuddleCamHD also offers a variety of other NDI®-enabled camera products including the SimpliTrack2. The SimpliTrack2 is an NDI®-enabled auto-tracking camera ideal for automatically following a presenter onstage or at presenter at the front of a classroom.



PTZOptics

PTZOptics is a live streaming camera manufacturer with options for SDI, HDMI, NDI®, and USB-connected pan, tilt, and zoom cameras. PTZOptics was one of the first manufacturers to offer NDI|HX® PTZ cameras. PTZOptics also offers NDI®-enabled box cameras and joystick controllers. It's known for its range of camera models that support up to 30X optical zoom, ideal for large spaces such as houses of worship, theaters, or educational venues.



Epiphan

Epiphan is a Canadian manufacturer of encoder and presentation switcher products. Epiphan offers a wide range of encoding, capture, and video switcher solutions. The Epiphan Pearl product line was the first product Epiphan offered with NDI® capabilities. The Epiphan Pearl, Pearl Mini, and Pearl Nano all offer NDI® support. Epiphan Pearl products are all-in-one video streaming and recording systems that are popular in education and live production.



LiveU

LiveU is the world's premier provider of live video transmission. LiveU is well-known for its cellular-bonded streaming products which allow broadcasters the ability to stream video from anywhere with a cellular connection. LiveU also offers a variety of content management solutions that offer NDI® output options. In this way, LiveU servers can capture content from anywhere in the world and make the outputs available via NDI® to production systems on the LAN network.



Teradek

Teradek is known for its wireless video transmission products. Teradek offers NDI® options for users to connect their wireless streaming solutions to a LAN for connectivity with NDI®. The Teradek Cube, for example, is a device that attaches to a camera which enables wireless

communication to a receiver and can then be connected to the network for NDI® video connectivity.



SONY

Sony is one of the world's best known video product manufacturers. Sony makes a line of PTZ cameras that are enabled with NDI® to give Sony users ethernet connectivity to simplify their camera setup. Sony cameras support Power Over Ethernet (PoE) which allows users to power a camera over ethernet, control the camera, and receive video.



Panasonic

Panasonic PTZ cameras support NDI® connectivity across a wide range of options. Panasonic also produces video switchers and PTZ camera controllers which support NDI®.

Tally-Lights



Tally-Lights is a manufacturer of Tally Lights which are available for vMix, Wirecast, OBS, and NDI® systems. Tally Lights are indication lights that are used with cameras to let on screen talent know which camera is live. Tally Light functionality is built into software such as NDI® Studio Monitor which will show a red border on any NDI® input that is currently being used for a live production in the output

area. NDI® Studio Monitor will show a green border when any NDI® input is currently in the preview area of a live production software. Tally-Lights NDI® controllers can power up to eight Tally Lights which can be paired with up to eight NDI® cameras.

Communications Software



Microsoft Teams

Microsoft Teams is used globally by businesses as a communication tool. Teams offers video communications, collaboration, and organization for teams of workers. Microsoft Team offers NDI® video outputs allowing the software to connect to other NDI® devices on a LAN.



Skype for Content Creators

Skype for Content Creators is a premium version of Skype designed to help creators easily access video from collaborators around the world and integrate it into their projects. Skype for Content Creators supports NDI® video outputs which allows you to bring FullHD video from Skype directly into other NDI®-compatible software and hardware.



LiveToAir by Gnural Net

LiveToAir is a video communication solution designed specifically for hosting video callers into live productions. While Microsoft Teams and Skype were designed for video communications, LiveToAir was designed for live streaming. In this way, the engineers at Gnural Net have included features for producers who are creating live shows. LiveToAir includes features such as a screening room, and of course NDI® outputs.



What about Zoom?

At this point you may wonder how you can use NDI® with Zoom. You may have heard about Zoom power users talking about how they use NDI®. In fact, using the NDI® Webcam Input, you can bring any NDI® source directly into Zoom.

Smartphone Apps



NDI | HX® Camera (Smartphone App)

You can add an additional camera to your production instantly with NDI | HX® Camera. With this software, you can turn any iOS or Android™ mobile device into a live video source by connecting to the same local area network as your NDI® hardware. Adjustable bandwidth modes allow for the best possible quality on the network. The application gives you complete camera control, including auto or manual focus and exposure, front or rear camera selection, and a built-in tally system.

NDI | HX® Capture (Smartphone App)

NDI | HX® Capture is designed for OS and Android™ mobile devices. The application allows users to capture the screen of any smartphone. This is ideal for presentations made from iPads or Android tablets. NDI | HX® Capture is also being used to capture video game content directly from smartphone screens. Once the app is running, the entire screen of the smartphone is made available as an NDI® output on the network. This output can then be made available to any NDI® software or hardware system on the network.

Conclusion

As NDI® technology continues to expand throughout the video production world, expect even more applications to become available. NDI® has made it easy for third-party software developers to include NDI® functionality in their software, creating endless possibilities for future development.

Key Takeaways:

1. NDI® tools are available for free. These tools, offered directly from NDI®, help make IP video easier to use.
2. A large number of software developers have integrated NDI® technology into their solutions.
3. A large number of hardware developers have products available to replace legacy HDMI and SDI video gear with modern NDI®-enabled solutions.
4. NDI® video can be used with any application that uses a webcam by using the NDI® Webcam Input.
5. NDI® video can be produced with most smartphone devices connected to the network via WiFi.

Chapter 5

USING NDI® AT THE STREAMGEEKS

The StreamGeeks are a small team of content creators from West Chester, PA, USA who produce live shows and video content all about live streaming. The StreamGeeks have been using NDI® in a variety of ways to produce video content, live streams, and fully featured webinars. In this chapter, you can learn realistic ways to use NDI®. You will see how the team at StreamGeeks uses NDI® to capture presentation materials, manage Zoom meeting participants, social media comments, and cameras. Each NDI® use case in this chapter is a practical, “get the job done” scenario.

Simple Presentation Slides

During most live streams and video recordings, the team at StreamGeeks creates a presentation. This presentation is made with Google Slides and then runs on a computer in the studio. The laptop is then connected to an HDMI monitor so that it can be easily seen from any camera angle in the studio. Using NDI® Screen Capture, the “Presentation Laptop” easily sends the presentation slides directly to the “Live Streaming Computer,” using the LAN.

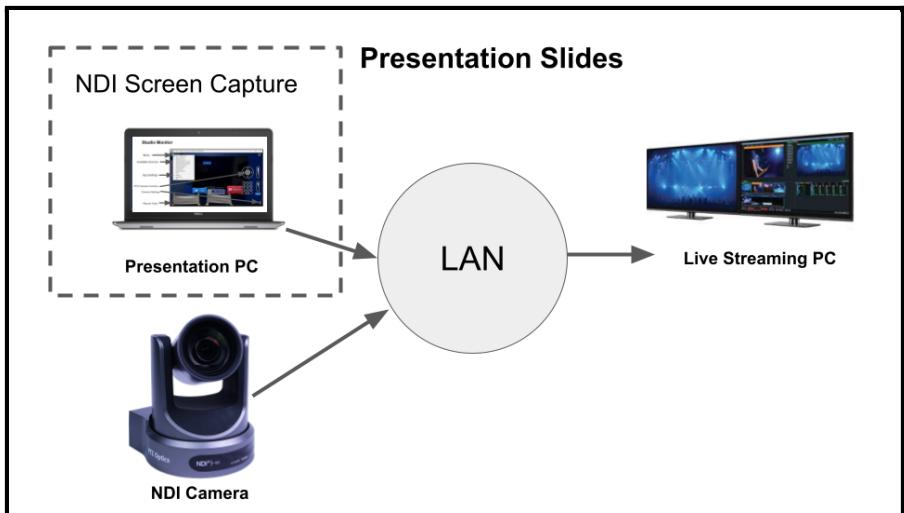
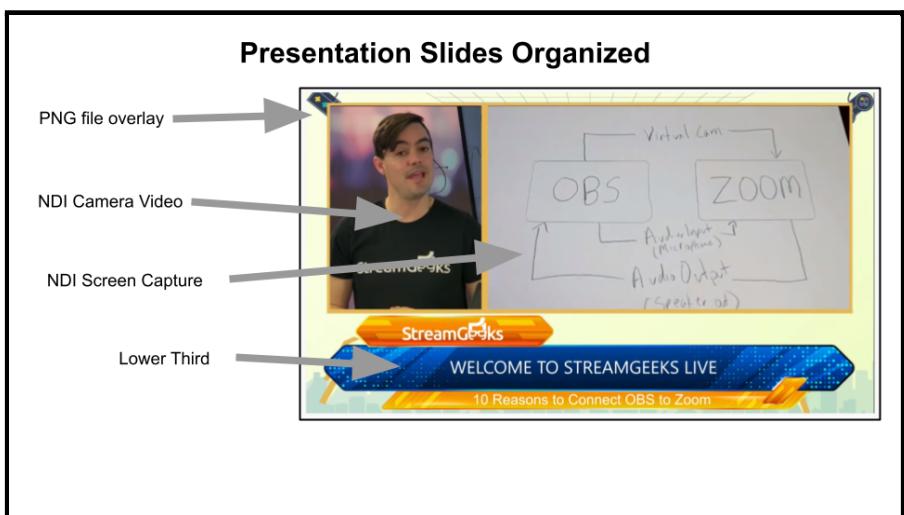


Diagram shows two computers on the same network using NDI®.

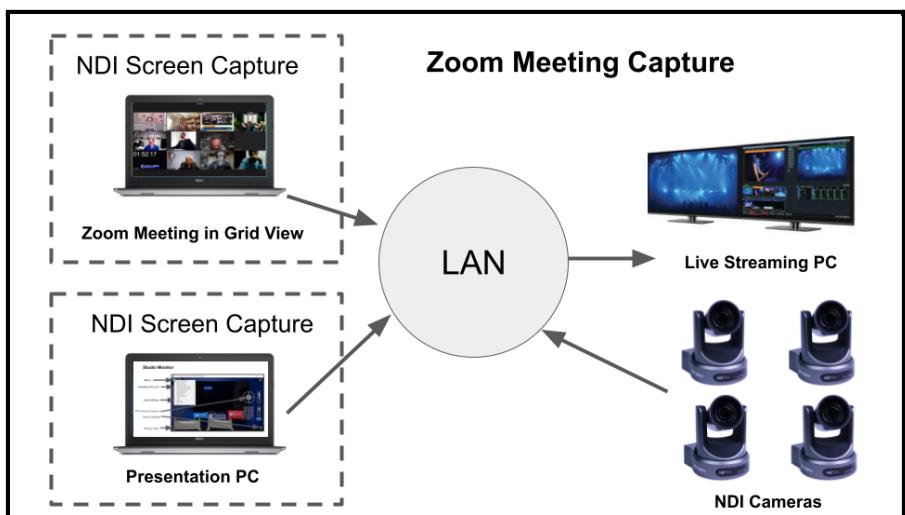
The live streaming computer uses vMix for video production. Inside of vMix, there are multiple NDI® camera inputs, an audio input, and a variety of other media assets. One of these media assets is a PNG file that is used to organize a live camera view and the presentation slides. You can see in the screenshot below how vMix is used to layer together two NDI® video sources.



The output of vMix with multiple NDI® video sources in a live show format.

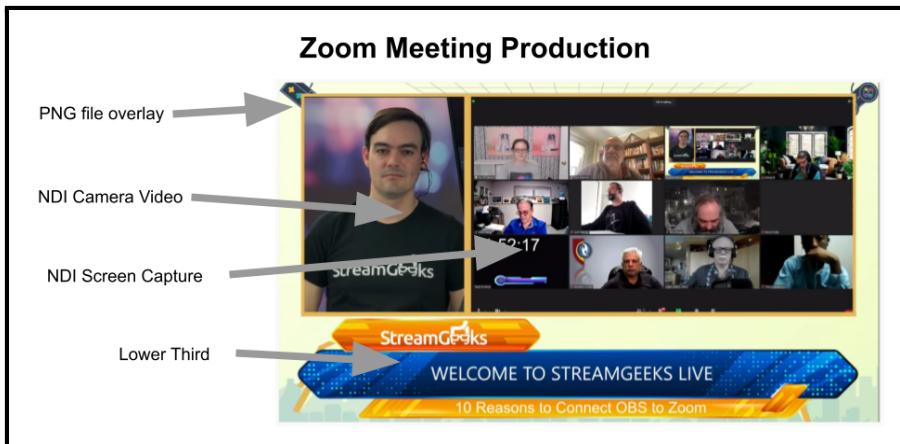
Many video productions are built from multiple layers of media sources. Local to the computer, there is a PNG file and a lower third. Underneath the transparent PNG file, there are two NDI® video sources that are connected over the network. This allows the producer the flexibility to create a scene where viewers can see the speaker next to their presentation but also cut to a full screen view of either the camera or the presentation at any time.

Capturing a Zoom Meeting



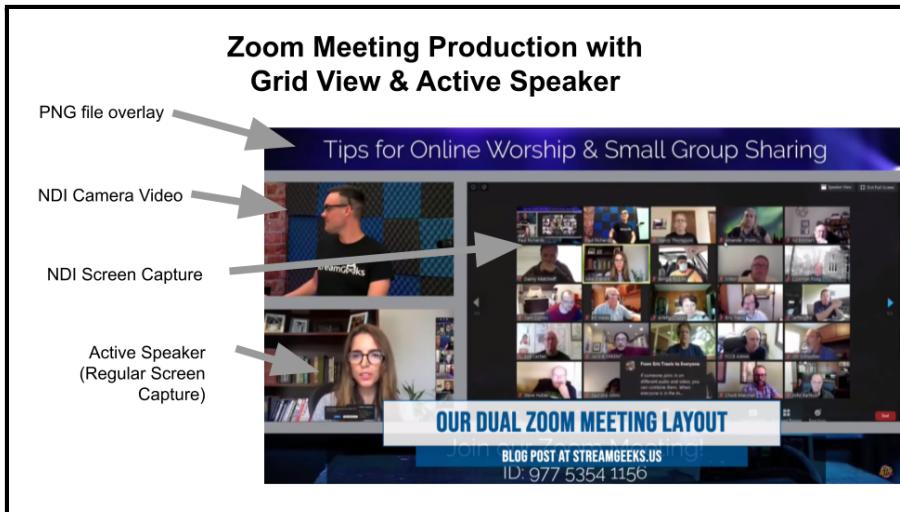
NDI® Screen Capture and a few more NDI® cameras.

The beauty of IP Video is scalability. The diagram above shows an additional four NDI® cameras and a second NDI® Screen Capture. It's customary to have a Zoom meeting going during the StreamGeeks' livestreams. This allows the team to connect with viewers in real time to answer questions and collaborate. Just like the presentation slides, the Zoom meeting is captured in a Grid View and made available to the producer.



Output of a StreamGeeks show with Zoom Grid View.

As you can see, NDI® video sources can easily be added to your LAN in order to provide more options for your production. The NDI® capture of Zoom meetings has become very popular. During a typical live stream, the StreamGeeks will also use a NDI® Webcam Input to bring NDI® video back into Zoom for guests who are not watching the livestream to view. To take this NDI® Zoom capture project one step further, you can see the next diagram includes two different video capture methods in the same Zoom meeting. How is this possible? Using multiple computers, the StreamGeeks will often connect to the same Zoom meeting to display the content in various ways.

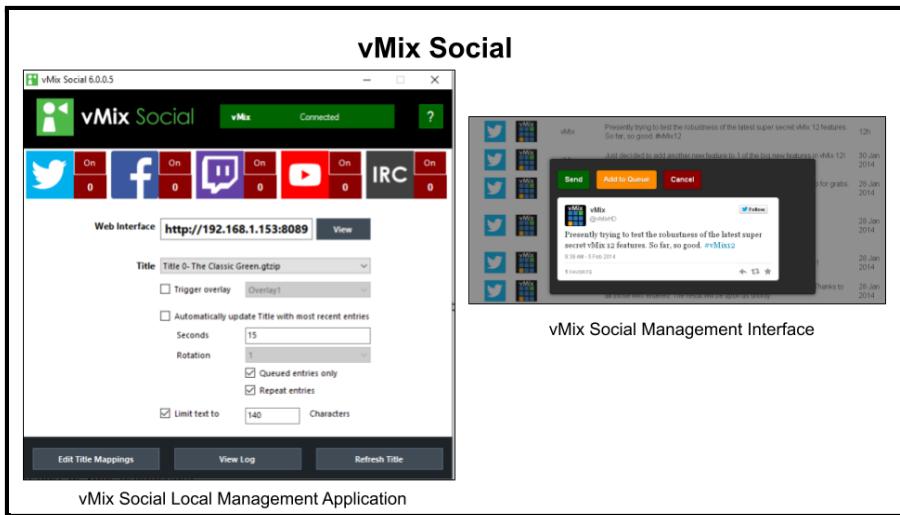


A Zoom meeting with an active speaker alongside the Grid View built from NDI® video sources.

During certain livestreams, it's nice to be able to show the active speaker in a larger window. And as a producer, it's good to have the active speaker in the Zoom meeting available as its own input to appear in a full screen. Here you can see the active speaker is actually shown in a regular screen capture. This means that vMix, or another type of software, is simply capturing a screen that is connected to the computer directly without NDI®. While this does take up precious monitor space, the StreamGeeks will often use NDI® on a separate computer to capture the active speaker view.

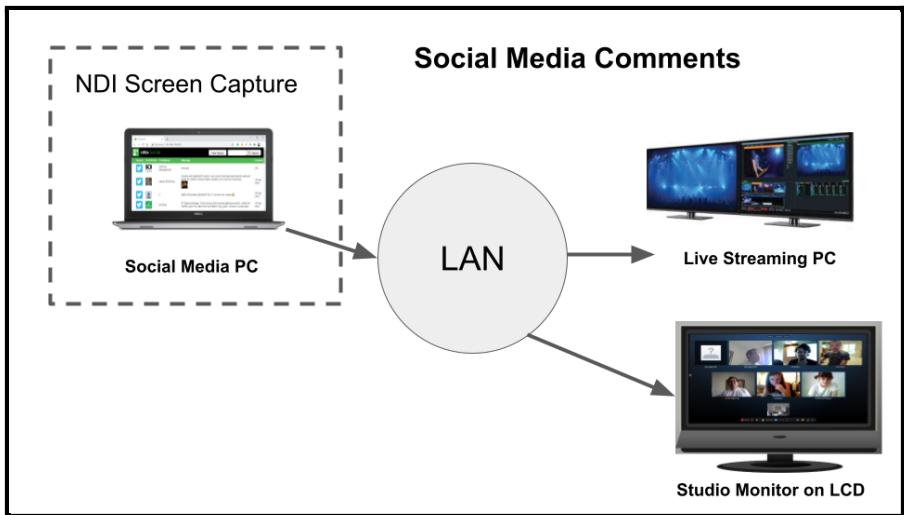
Working with a Team

One great way NDI® has helped the team at StreamGeeks grow is through shared responsibilities. In the studio we have the ability to share video sources and production-related responsibilities. One way that our team shares responsibilities is by managing who is responsible for a specific NDI® video feed that is being sent to the production. The presentation slides are one example, but another is the management of social media content and in-studio displays.



Here, you see two vMix social interfaces. On the left is the main application that runs on a Windows computer and on the right is the web-interface used for control.

To manage social media comments, the team uses vMix Social. There is a main vMix Social application that is used to authenticate accounts with social media platforms such as Twitter, Facebook, Twitch, and YouTube. Once set up, this application has a web interface that can be used by anyone on the LAN. The web interface will show all social media comments coming in from the connected social media networks. From here, the user selects a comment to show onscreen. While vMix Social is a great tool, it's too much for our producer to manage while also running the livestream. Therefore, a second social media manager is necessary.



The social media manager sends video directly to another vMix computer on the network while also controlling an LCD screen with Studio Monitor.

The diagram above shows how the social media manager is able to manage a separate vMix instance and connect that video to the main livestreaming computer using NDI®. Running a second instance of a video production software like vMix, OBS, or Wirecast allows a secondary livestreaming operator to contribute to the production. This can look like a simple lower third, or a full screen of video. In fact, the social media manager also controls the video on an LCD screen in the studio. To do this, the social media manager remotely controls Studio Monitor using the web control interface. This allows the social media manager to switch between a grid view of the Zoom audience and other content that may be beneficial to the production. In practice, this is often used to seamlessly switch between social media comments and the audience coming through via Zoom.

Using NDI® this way is ideal for many organizations that seek to add volunteers to their team. NDI® will allow anyone with a computer and some technical skills to contribute to the video production.

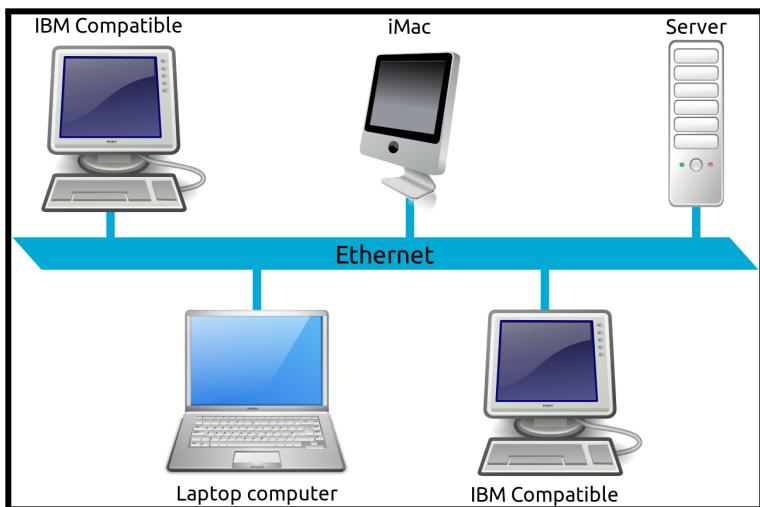
Key Takeaways:

1. NDI® is a technology that makes it easier to implement high quality video productions.
2. The StreamGeeks use NDI® in most live video productions from their studio.
3. NDI® makes it easier to work with a team and allow others to contribute content.

Chapter 6

WHAT IS A LOCAL AREA NETWORK?

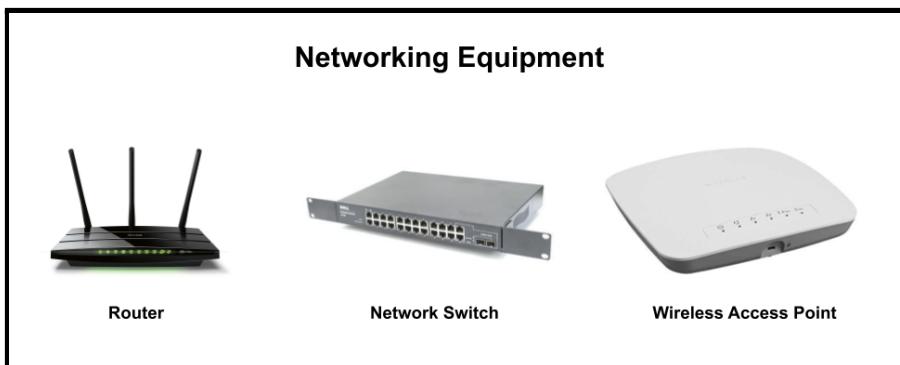
The purpose of this chapter is to provide a basic understanding of how IP networks are set up with respect to video production. In this chapter, you will be challenged to think outside the box about how to plan live streaming and video production systems in the world of IP. Using standard networking infrastructure, NDI® will enable you to think about video technology in a new way.



A network of computers.

At the heart of NDI® connectivity is your local area network (LAN). A LAN is a group of computers and other hardware or devices that are connected using established networking protocols. These devices may be connected using ethernet cables or via WiFi connectivity. A LAN can be as simple as a computer, tablet, or printer connected on a basic home network, or as complicated as hundreds of computers and devices in an office building. All computers and devices connected with networking equipment are considered part of a local area network. Outside of the LAN is the wide area network (WAN). An Internet

Service Provider (ISP) provides LANs with a secure connection to the WAN which delivers internet access.



Common types of networking equipment.

A router is a common type of networking equipment which provides a safe communication space for computers connected to the network to access the internet. The rules of the LAN are generally managed by the router which has a management page that can be accessed securely by a computer on the network. The router manages the other computers and devices on the network and can even give devices IP addresses automatically using a protocol called Dynamic Host Configuration Protocol (DHCP). Some routers include a built-in network switch, but most are connected to a larger network switch which provides connectivity between all of the devices on the network. Some routers include WiFi connectivity with a built-in Wireless Access Point (WAP). Many networks distribute WAPs throughout an area to provide WiFi connectivity throughout a large space. Each WAP should be connected to the network with ethernet cables and many are Power Over Ethernet (PoE) capable. A PoE device can be powered by PoE enabled networking equipment using standard ethernet cables.

Below is an example of an IP address table. It's important that you are organized when it comes to managing the 254 IP addresses available on a single IP range, in order to effectively manage your LAN.

IP Address	Device
192.168.1.0	This is the network number that identifies the network as a whole.
192.168.1.1	This is assigned to the router
192.168.1.2-254	These addresses may be assigned to devices on your network.
192.168.1.255	This is the broadcast address. Anything sent to this address is automatically broadcast to IP addresses 1-254.

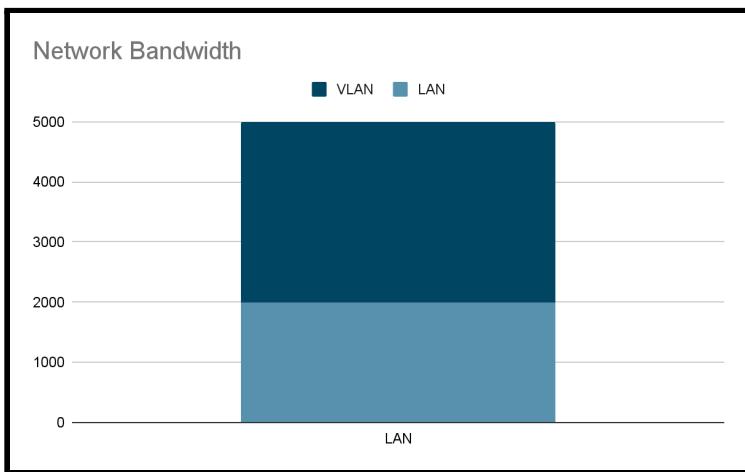
Don't worry if the IP addresses on your network are different. The starting numbers can vary depending on how the network is set up.

Besides the computers and devices that are a part of the network, LANs require additional hardware to keep everything connected. In a home or small office, the network may be managed by a single router. ISPs often provide multipurpose all-in-one routers that offer access to the internet (via cable, fiber, or other connection). They also provide a wired and/or wireless network connection that enables connected devices to communicate with the internet and other devices on the LAN. Larger and more robust LANs may require additional hardware such as routers, switches, firewalls, and wireless access points. Professional-grade equipment at this level allows for more devices, better security, and network management.

There are several possibilities regarding the type of LAN you will be using for your NDI® set-up. In many cases, you will use your existing network. In that case, it will just be a matter of ensuring that your network is correctly configured and has the necessary capacity. In large organizations with more complex LANs, you may need to work with a network administrator to ensure that your NDI® devices and software have the required access and permissions. A network administrator can also help assign the correct IP address to communicate across the network and ensure that there's enough available bandwidth to handle your set-up.

In some situations, the administrator can also prioritize video traffic to avoid latency issues when there is too much traffic on the network. You

may need to set up your own network for use specifically with NDI®. It's possible to connect a computer to multiple LANs at the same time. This is easy to do if your computer has two Network Interface Cards (NICs). If your computer only has one NIC, you can purchase a USB to ethernet adapter to add an additional NIC port to your computer. Adding an additional NIC port will increase the amount of bandwidth your computer can access. Because NDI® can load balance multiple NIC cards on a computer, this is an easy way to increase the amount of NDI® sources you can use for your video production.



This example LAN shows bandwidth partitioning for a VLAN.

A virtual LAN (VLAN) can be used to set up a segmented part of a network specifically for NDI. Network administrators can set up a VLAN to partition resources inside of a larger LAN and provide additional reliability and security. VLANs are ideal for limiting network access to specific computers. A VLAN is ideal for NDI video traffic because you can reduce network traffic and the potential for packet collisions. Most networking equipment allows you to create a large number of VLANs. Each VLAN can be set up with access to specific resources on the network. The example above shows a VLAN that has been set up within a 5 gigabit network. The example VLAN has been set up with access to 3 gigabits of bandwidth.

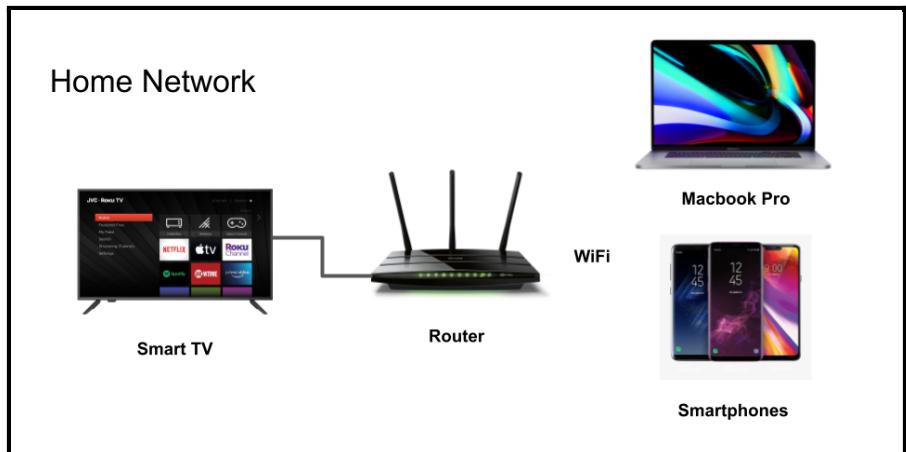
Networking equipment does have limitations which are important to understand when you're working with NDI® video. NDI® is designed

to work on networking hardware that supports gigabit or greater transfer speeds. But what is a gigabit? Bits are units of measurement used to represent data transfer. Gigabit networking hardware can send and receive 1,000 megabits of data every second. Ten-gigabit networking hardware can send and receive 10,000 megabits of data every second. NDI® video traffic will use this available bandwidth on your network to send and receive video. Therefore, it's useful to know how much bandwidth each NDI® video source will require and the maximum amount of bandwidth available on your LAN.

House of Worship Example

The following example will outline a video production network setup for a house of worship. For this example, a part of the network has been segmented for devices that are used for video production such as cameras and computers running video production software. Each device on the network has an IP address and in general, there are two different ways that you can assign devices IP addresses. They can be assigned a static IP address manually, or a dynamic IP address automatically. Static IP addresses never change, and therefore they are much better for managing an IP address table on your network. Dynamic IP addresses are assigned by your router using Dynamic Host Configuration Protocol (DHCP). This protocol is ideal for devices that periodically connect and disconnect from your network. A smartphone is a prime example of an IP-connected device that uses DHCP. When your smartphone connects to WiFi, it automatically gets an IP address from the network. It's a best practice to assign static IP addresses to the most important devices on your network used for video production. It's especially important to use a static IP address for devices like PTZ cameras that are permanently installed on your network.

Without getting too far into networking jargon, you can have up to 254 devices on a single network which can all communicate on the same IP range.



Home networks don't generally require a lot of networking hardware.

A simple home network like the one above uses a router provided by an ISP. This router includes a built-in network switch, a firewall, and a WiFi access point. A router like this will allow you to connect a few devices to your network right away such as a smart TV, smartphone, and a few computers. All-in-one routers are becoming more popular and affordable and can also be used with NDI®.



Affordable NDI® networking equipment set-up video on YouTube.

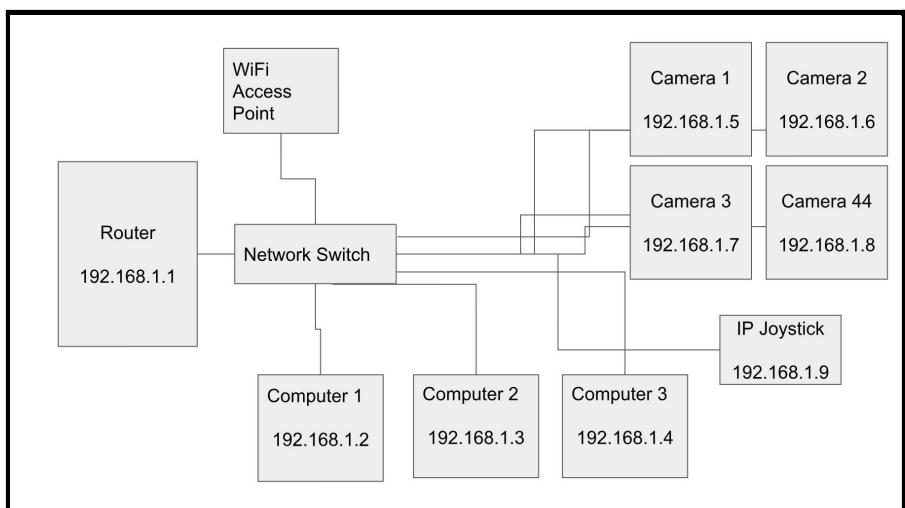
One popular networking set-up for NDI® comes from TP-LINK. The

StreamGeeks tested the TP-LINK Archer series of routers for use with NDI®. This “All-In-One” wireless router offers specific settings that work with multicast and IPTV for video routing. You can scan the QR code above or watch the video in the online course to learn more about this set up. Even if you end up using different networking equipment, the six- minute video outlines all the steps required for most routers to be optimized for NDI®.

As your interest in using NDI® grows, you will likely want to purchase a dedicated network switch that will allow you to plug multiple devices into your network. Your network switch should be connected to a router with an ethernet cable. Some network switches are “managed,” meaning that they have some smart capabilities similar to a router. Remember that ethernet cables can become a bottleneck in your bandwidth access and you should always select ethernet cables that match the bandwidth capabilities of your network infrastructure..

Note: If you plan to power cameras and other devices using ethernet cables, you will want to purchase a network switch that supports Power Over Ethernet (PoE).

The next diagram shows that each device on the network is connected to a network switch. This network switch has PoE connectivity and it can power small devices such as PTZ cameras and joystick controllers.



High-level networking diagram with IP addresses for each device.

The table below is helpful for referencing IP addresses when you need them. For example, if a PTZ camera is controllable with your video production software, the camera's unique IP address is often necessary to control it. Some software with web-server capabilities will use a port number to create a unique address for the software running on the network-connected computer. For example, if your main live streaming computer is running vMix, you may be using the vMix Social application which is controlled by a web-browser interface. If the computer's IP address is 192.168.1.70, vMix will automatically use port 8089 on the same base IP address to create a unique address to control vMix Social. Therefore, the IP address 192.168.1.70:8090 would open the controls for vMix Social.

IP Address	Device
192.168.1.0	Network Address
192.168.1.1	Router supplied by your Internet Service Provider
192.168.1.2-59	Used for office devices like office computers, printers, access points, and other IP connected devices
192.168.1.60	PTZOptics 20X - Main Camera in back of Church
192.168.1.61	PTZOptics 12X - Front Camera on Choir Area
192.168.1.62	PTZOptics 12X - Side Camera to on Stage
192.168.1.63	PTZOptics 30X - 2nd Camera in back of Church for Close Up Views
192.168.1.64	PTZOptics ZCam - Static Camera used for Drum Cage
192.168.1.65	PTZOptics ZCam - Static Camera used for Backstage
192.168.1.66	PTZOptics IP Joystick Controller
192.168.1.70	Main vMix Live Streaming Computer
192.168.1.70:8089	vMix Social Management Server

192.168.1.71	Pastor's on-Stage Laptop
192.168.1.72	Computer Powering 2 Displays in Lobby using NDI® Studio Monitor
192.168.1.73	Computer Powering 2 Displays in Nursery using NDI® Studio Monitor
192.168.1.74	Computer Powering 2 Displays on Stage for Confidence Monitoring
192.168.1.119*	iPad using NDI® Camera App (Wireless Camera)
192.168.1.123*	Smartphone used for iOS camera control app
*Assigned with DHCP	

The great thing about IP-based video production for so many NDI® users is that you likely already have a network in place at home.

Thinking about your home network may help you make sense of the chart above. You may open up a whole new universe of possibilities where your existing network becomes the preferred method of video routing across your facility.

Need another camera shot? Just run a Cat-5e cable to an NDI® camera. This single cable will give you a high-quality video, a camera you can remotely control, and power for that camera in a single stroke. Want to send PowerPoint slides from a computer onstage back to the video production computer? No problem, everything is connected to the same network. Try using your home network with the NDI® mobile app on your phone and see how easy it is to send video from your smartphone to your computer connected on the same network.

This is where the rubber meets the road for most NDI® users. Unlike Serial Digital Interface (SDI) and High-Definition Multimedia Interface (HDMI) cabling, ethernet provides power for cameras using a PoE source, such as a PoE switch. It will simplify installations and eliminate the need for additional outlets where you would have had to hire an electrician in the past. And unlike traditional camera control cables, ethernet can also be used to control cameras and devices within your

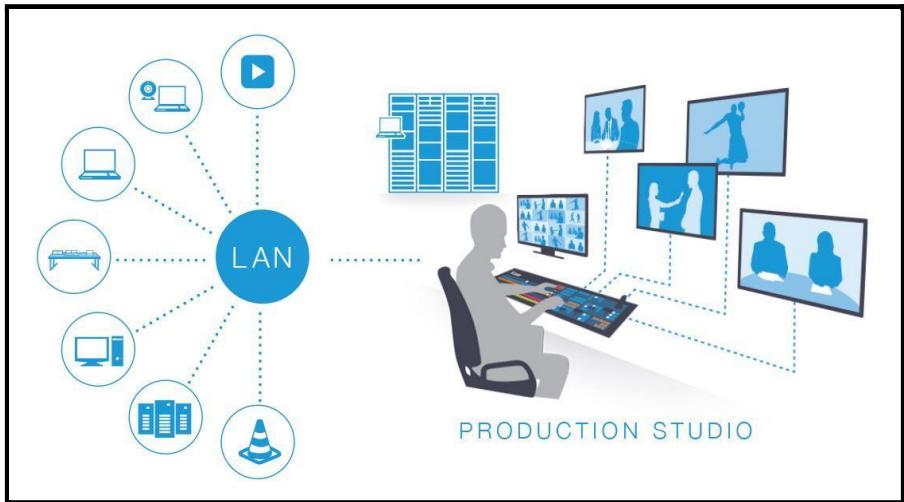
favorite video production software. You can even use an IP joystick without direct analog control cabling for each camera.

Key Takeaways:

1. A local area network (LAN) is a network of interconnected computers.
2. Common networking equipment will create a LAN in which multiple computers can communicate.
3. NDI® uses a LAN to send and receive video from one computer or device to another.
4. Each device on the network should have an IP address which is used to deliver information from one device to another.

Chapter 6

BANDWIDTH CONSIDERATIONS



A modern video production system connected to a Local Area Network (LAN).

At this point you may be thinking, what's the catch? The main bottleneck most NDI® users confront is a limitation of bandwidth on the network infrastructure. Three areas where bandwidth can be limited include the ethernet cabling, networking equipment (router, switch, or wireless access point), and the Network Interface Card (NIC) port on the computer. Ethernet cables are therefore at the heart of many IP-based video production systems. Ethernet cables don't usually extend beyond 328 feet (100 meters), though they come in a variety of quality types noted below.

Category	Bandwidth
Cat-5	100 Mbps

Cat-5e	1 Gbps
CAT6	10 Gbps
CAT7	10 Gbps
CAT8	25 Gbps

Most video production setups that use ethernet for video connectivity require CAT 5e cabling or greater because regular Category 5 cabling only supports up to 100 megabits per second of data transmission. CAT 5e supports a full gigabit, or 1,000 Megabits, of data transmission. Higher end CAT cabling can offer up to 25 gigabits of data per second.

Ethernet connections are easy and convenient to use for a variety of applications. For one thing, network connected devices can provide bi-directional connectivity to send and receive communication. You can also connect all the devices on your network to the internet, opening up many possibilities for connectivity around the world. Most commonly installed networking equipment supports gigabit connectivity, but higher bandwidth networking gear is becoming more common every day. Unfortunately, if you have 10/100 networking infrastructure, you will have a hard time using it for IP-based video production. There simply isn't enough bandwidth on these older networking systems to support HD-quality video transmission.

The good news is that gigabit networking equipment has become the industry standard and there is a good chance that this is the type of technology you have already installed. A gigabit network switch with a full throughput backplane can send approximately 1,000 megabits of data to each device on your network. You should never use 100% of the available bandwidth on your network because you need to reserve “headroom” to avoid network congestion and failure. Network bandwidth headroom recommendations can vary widely but generally, most IT professionals recommend 30% to 60% depending on what the network is used for. Consult your network administrator before adding

IP video traffic to your LAN. NewTek suggests NDI® traffic should not take up more than 75% of the bandwidth of any network link.

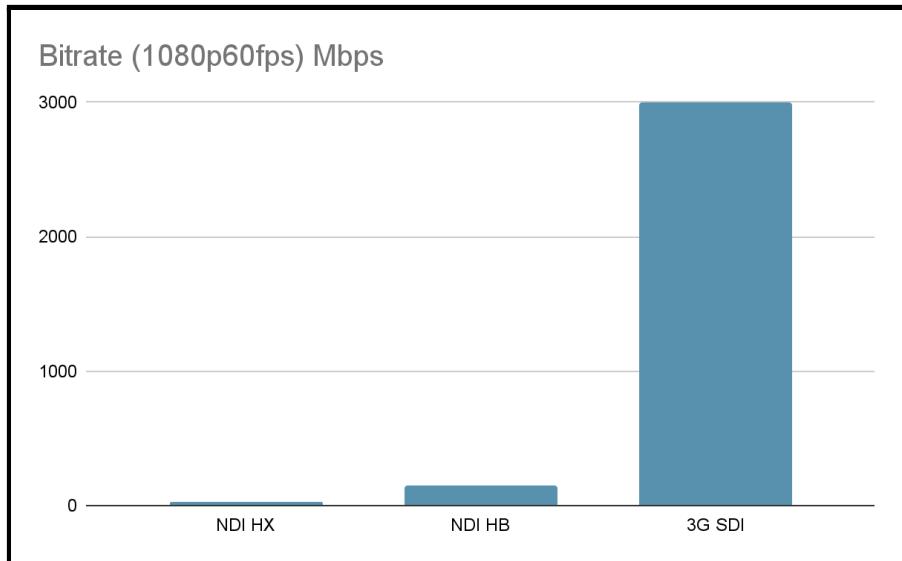
There are many different types of network switches that can support various levels of bandwidth. While gigabit is the most popular, today you can purchase a 10-gigabit ethernet switch that provides transfer speeds of 10,000 megabits per second. Access to higher bandwidth devices will become more and more common.

NDI® Mode	Bandwidth
NDI HX® Low (720p60fps)	6 Mbps
NDI HX® Medium (1080p30fps)	8 Mbps
NDI HX® High (1080p60fps)	12~22 Mbps
NDI® HB (1080p30-60fps)	125-200 Mbps (Nominal Range)

Note: actual bandwidth usage may vary.

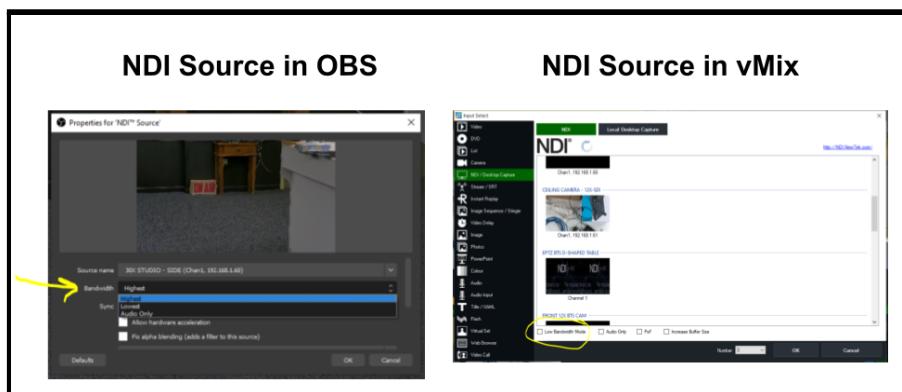
Knowing how important bandwidth is to any NDI® project, it's nice to know that you have some options to optimize bandwidth. The chart above shows the two main types of NDI® video: NDI® HB and NDI | HX®. NDI® HB is considered the full bandwidth version of NDI® which can take a 3 gigabit, fully uncompressed video signal, and compress it down to 125-200 megabits without producing noticeable digital artifacting. This type of compression is what makes IP video production possible on a gigabit network infrastructure.

In most cases, the compression effect is “unnoticeable” to the human eye and seeing the video side-by-side is a worthwhile experience. The final destination for many live video sources is a content distribution network like Facebook and YouTube. Therefore, many users already plan to compress the entire video stream with Real Time Messaging Protocol (RTMP) or Secure Reliable Transport (SRT) before it reaches viewers.



Compression reduces the bitrate of NDI® HB and NDI | HX® as compared to an uncompressed 3G SDI 1080p60fps video signal.

To further advance what's possible with IP-based video production, NDI® released the “High Efficiency” version of NDI® called “NDI | HX®.” This version of NDI® can compress a 1080p video source down to a mere 8-50 Mbps depending on the quality selected. NDI | HX® is available in compression ratios of low, medium, high, and ultra depending on the source. All NDI® sources include a “low bandwidth” option that is available in most NDI® compatible software and hardware solutions.

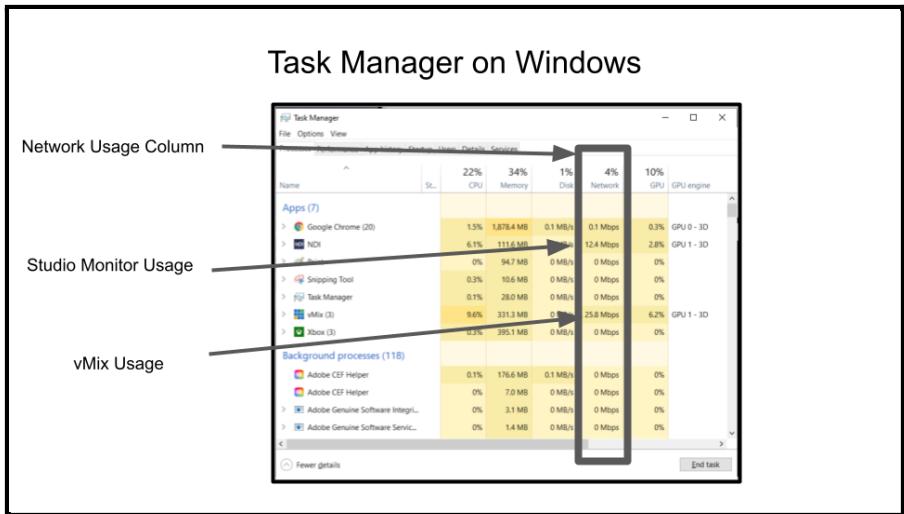


NDI® sources in both OBS and vMix.

Computers' with limited bandwidth or processing capabilities can quickly connect to NDI® sources in low bandwidth mode. This is easily accomplished in most video production software solutions that support NDI®. For example, when you add an NDI® input in OBS, you get the option for "Highest" or "Lowest" bandwidth. Inside of vMix, you can switch to low bandwidth mode by right clicking the input. In fact, vMix allows you to discover NDI | HX® sources and swap them on the fly. This is a great way for producers to conserve bandwidth and computer performance and connect to new sources on the network.

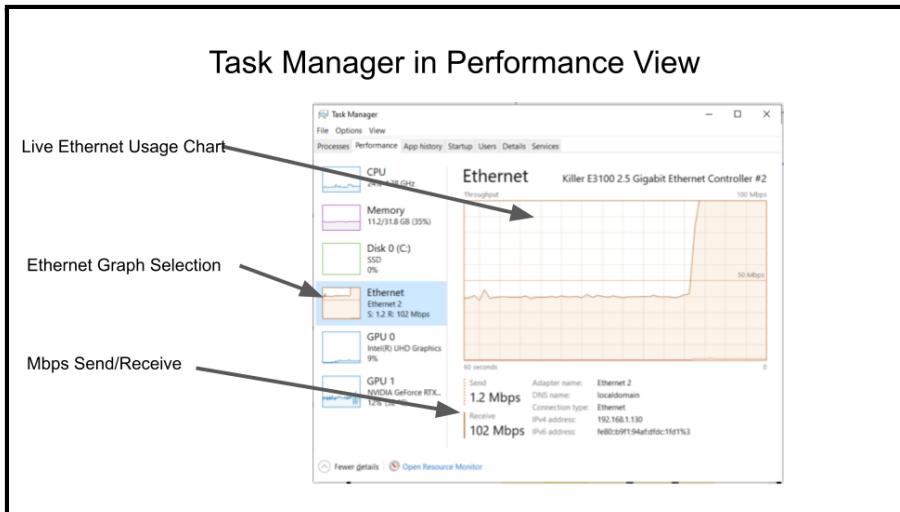
Pro Tip: Make sure to clearly name each unique NDI® video source on your network. When you are reading through a list of NDI® sources it is helpful to have groups of sources organized into categories. When you create NDI® groups, each source will be nested inside of an organizational group which is discoverable in the network.

As you can see, there is a big difference between using NDI HB® and NDI | HX® sources on a network. While each NDI® source will take up available bandwidth when it is used, NDI® sources that are not in use will not take up any bandwidth. Therefore, you can think about NDI® video sources like sockets that you can connect to at any time. When you connect to an NDI® source, you are adding bandwidth through the computer's incoming Network Interface Card (NIC).



Task Manager can be used on any Windows computer to look at applications running on your computer.

To visualize this idea on a Windows computer, open your computer's Task Manager and look at the network utilization percentages for each process on your computer. Look at Activity Manager on a Mac computer to do the same thing. In Task Manager, there is a column that shows the network usage for the computer's NIC. There is also a "Performance" view to see bandwidth usage on a chart as shown below.



Task Manager appears in the Performance view with Ethernet selected.

The table below shows a common NDI® video use case. In this example, you will get a sense of how bandwidth accumulates in an NDI® production environment.

Example:

NDI® Device Examples (1080p60fps)	Bandwidth	Accumulated Bandwidth	Total % of Gigabit Network Switch
NDI® Screen Capture on Laptop for PowerPoint slides	125 Mbps	125 Mbps	12.5%
2 x NDI® Monitors for camera operators	125 Mbps / Each	375 Mbps	12.5% / Each

THE UNOFFICIAL GUIDE TO NDI®

vMix System output in 1080p60fps	125 Mbps	500 Mbps	12.5%
NDI® Monitor in Overflow Room	125 Mbps	625 Mbps	12.5%
5 x PTZOptics NDI HX® (High)	12 Mbps / Each	685 Mbps	1.2% / Each
Suggested Headroom	250 Mbps	910 Mbps	25%
Total Usage			91%

As you can see, the bandwidth required for IP video projects easily adds up. Because networking equipment is so much more affordable than traditional switching hardware, many NDI® users find themselves building networks for video production.

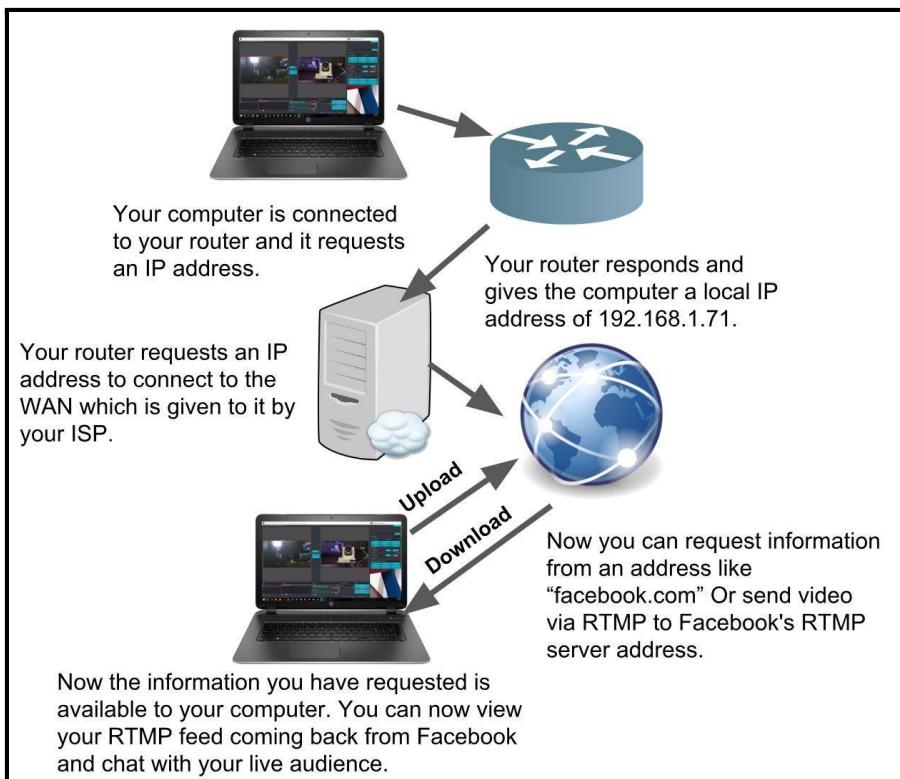


Diagram shows how your computer is connected to the internet and livestreams to Facebook.

The diagram above shows how your computer is connected to your local area network. Each device connected to the LAN can request and receive information from the internet through your router. Until NDI® 5.0, almost all NDI® video traffic happened inside of the LAN. Today, NDI® Bridge and NDI® Connect allow you to securely connect with video sources outside of your LAN.

In order to livestream from inside a LAN, computers use upload bandwidth to stream video to a Content Delivery Network (CDN) such as Facebook. Once the livestream is hosted by a CDN, your computer can use download bandwidth to preview the live stream and view comments from live viewers. A video production software running on your computer like OBS or vMix, can connect to multiple NDI® sources on your LAN and then uses those sources to produce a live

stream which goes out to the world using RTMP. RTMP is the primary protocol used for encoding video sent over the public internet to CDNs like YouTube.

Esports Example

Imagine you have a few computers where you want to capture video games being played onscreen. Once the video is captured, you want to send it to another computer on your network to show on a large screen. You may also have an additional computer that produces a basic live stream that you send out to YouTube and Twitch. The main NDI® Screen Capture application would be a good choice to capture the video gaming screen if you have the available bandwidth. In fact, you can also capture a webcam video feed at the same time if you wish. You could also use the new NDI | HX® Screen Capture tool as well. The NDI | HX® Screen Capture app will allow you to send the video with a lower bandwidth. With either screen capture tool, you can connect the video streams from the gaming computers into your production computer. The production computer can then add graphics, mix in some webcam video feeds, and output the production via NDI® for the local display and RTMP for YouTube and Twitch.

There are a couple of ways that you can display the video from the esports production on a large display. The easiest way is to use the production computer with an available HDMI output. If the display is too far from the computer, you can use a second computer on the network running Studio Monitor to display the live production. You can also use an NDI® to HDMI decoder instead of a computer. NDI® decoders can be connected directly to an HDMI or SDI source, in order to turn any NDI® video feed on the network into an HDMI or SDI video output.

NDI® Device Examples (1080p60fps)	Bandwidth	Accumulated Bandwidth	Total % of Gigabit

			Network Switch
NDI HX® Screen Capture (x6) Set to 20Mbps	120 Mbps	120 Mbps	12%
1 x NDI® Monitors	125 Mbps	245 Mbps	24.5%
iOS NDI® camera	125 Mbps	370 Mbps	37%
3 x PTZOptics NDI HX® (High)	20 Mbps / Each	430 Mbps	43%
Other Normal Traffic	250 Mbps	680 Mbps	68%
Total Usage	580 Mbps	--	68%
Suggested Headroom	250 Mbps	--	25%
Total Bandwidth	680 Mbps	680 Mbps	68%

One easy way to add a camera to the production is with a smartphone using the NDI® camera app on an iOS or Android device. To do this, connect your smartphone to the same WiFi network as the production computer. Later in this book, you will learn about some easy to use network routers that include WiFi perfect for connecting smartphones for video.

Finally in this example, there are three PTZOptics NDI|HX® cameras connected on the network. These cameras can be used to capture the esports action happening around the event which may also include a broadcast desk and shoutcaster area. A shoutcaster area is a space where an esports production has an announcer host commentary about the game. PTZ cameras are ideal for productions like these because they can be controlled over the network using a computer or

smartphone. One PTZ camera can be used to zoom into various locations to provide multiple angles.

As you can see, NDI® requires some networking knowledge. But, in general, anyone can set up and use off the shelf networking hardware to create a powerful IP video system. However, many video production professionals prefer to set up their own portable network for on-location work. You should never assume that a network will be available for you to use on-site.

Be sure to read the network connection requirements below carefully. Keep in mind that the more you add to your NDI® production workflow, the more network bandwidth you will need. A dedicated gigabit (1,000 Mbps) network or greater is the preferred option to get the most out of complex NDI® setups.

Minimum System Requirements

Minimum system requirements vary for different NDI® applications. The following requirements are for the most basic NDI® tools. More complex applications and workflows will require more robust systems.

Windows:

- 64-bit Microsoft Windows 7 operating system or later
- Intel i5 Sandy Bridge CPU or better with integrated GPU (NVIDIA discrete GPU, with 2GB video memory or better recommended)
- 8GB system memory
- Gigabit Ethernet connection or better

Mac:

- Mac OS X operating system or better
- Intel Core i3 CPU or better (Intel i5 CPU or better recommended)
- 6GB RAM or better
- Gigabit Ethernet connection or better

Network Connection Requirements

A gigabit networking infrastructure is recommended for use with NDI®. A single stream of video in High Definition can use between 100-200Mbps of bandwidth. For more resource-intensive production workflows, five or 10 gigabit networks may be required. For the best possible performance, NDI® should be used on a dedicated network. When this isn't feasible, a managed network where NDI® data can be prioritized will still see better performance than operating on a shared, or unmanaged network.

Networking:

- Gigabit Ethernet
- Full Throughput Switch Backplane
- Dynamic Host Configuration Protocol (DHCP) Recommended
- For devices that optionally support PoE
 - PTZOptics NDI | HX® Cameras require PoE (15.4w)
 - NewTek Connect Spark requires PoE (15w)
 - Note* PoE+ network switches supports PoE, but PoE doesn't support PoE+
 - Make a note of the power needed for devices/switch
- *More on WiFi in an upcoming chapter.

Managed Switches:

Managed switches are great, but the settings available may need to be tweaked to accommodate low latency IP based video for production. You can use almost any gigabit managed switch that meets the requirements above, but you may have to disable a few settings and enable Flow Control as Asymmetrical.

- Disable Quality of Service
- Disable Jumbo Frames
- Enable Flow Control as Asymmetrical or Simply as On
- Enable IGMP Snooping if Using Multicast (mDNS)
- Configure IGMP Querier and Query Interval Per Switch in Multi-Switch Networks (While Using Multicast)

Firewalls:

- mDNS must be accessible
- Manual discover requires access to port 5960 for messaging and all coming after 5961 for streams

Network Adapters:

- Use DHCP to assign IP addresses or assign static manually
- Use manual configuration in NDI® Access Manager to cross subnets
- Designate network location on all NICs as Work (private)
- Connect and available Gigabit + network interfaces

Latency:

- Full circle latency must be <14ms
- NDI® v3.5 and later supports UDP with Forward Error Correction for unicast (prior versions use TCP)

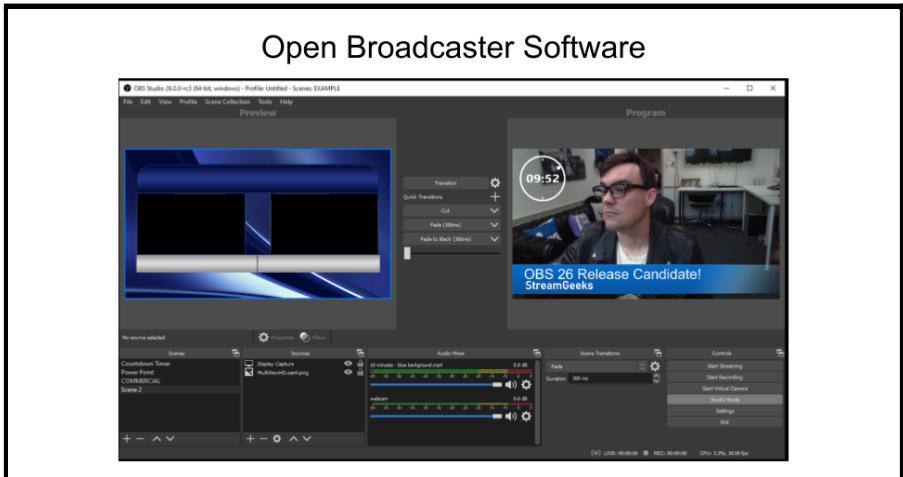
Key Takeaways:

1. Bandwidth is required to send data between computers on a shared local area network.
2. NDI® requires gigabit (or better) networking equipment. A gigabit provides 1,000 megabits per second of data transfer.
3. There are multiple types of NDI® sources which have various bandwidth requirements.
4. NDI® video streams can use over 100 megabits of bandwidth while NDI|HX® video sources can be used to conserve bandwidth.
5. NDI® video streams are compressed in order to be sent over a network in-between computers. In general, the more compression that is used, the lower the video quality will become.
6. When you are planning an IP video system, you should consider the bandwidth requirements and plan extra headroom.

Chapter 7

THE OBS EXAMPLE

Open Broadcaster Software (OBS) is an open source video production software project that has become the most popular live streaming and video production solution in the world. The software provides an open workspace for creating, recording, and streaming video in a live production environment. OBS is free, yet it supports an unlimited number of sources and scenes which is why it has become so popular. OBS has become the standard for live streaming video gaming, but also many other types of live productions including worship services, theater, events, live sports, talk shows, and more.



The Open Broadcaster Software interface in Studio Mode with two screens: one for Preview and the other for Program Output.

The OBS project was started by Hugh “Jim” Bailey in 2012. The open source nature of the project has attracted a grassroots community of developers that helps maintain and increase the functionality of the software. OBS can be installed on any Mac, PC, or Linux computer from OBSPProject.com. In 2016, a developer by the username of Palakis

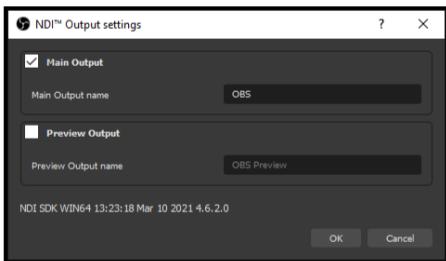
released a plugin for OBS that added support for NDI®. OBS plugins are software add-ons that extend the functionality of OBS by adding open source code. Once a plugin is installed, new features are made available in the OBS interface. As of early 2021, 1.5 million users had downloaded the NDI® plugin for OBS. The plugin offers users NDI® inputs and outputs which generate a new world of possibilities for OBS users.

It's worth noting that OBS will never have native support for NDI®. All code in the OBS project must be 100% open source. NDI® itself is royalty-free, but the code is not open source. Therefore, the plugin provides a legal way for OBS to interface with NDI®. So why is OBS so important to the NDI® ecosystem overall? NDI® essentially opens up thousands of new video input and output opportunities for OBS users. Because OBS is free, it has become a go-to solution for creating NDI® video and sending it out into a LAN.

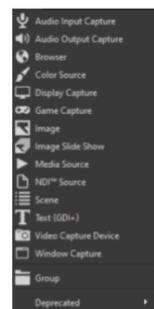
How does NDI® work in OBS?

Once you have installed OBS and the NDI® plugin you can use NDI® in three ways. First, you can set up OBS to send the preview and output screens in the production software as NDI® outputs. This is an easy way to capture and distribute your OBS content via NDI®. The second option is to bring NDI® sources into your OBS production. This is useful for connecting multiple OBS software instances, or using OBS with some of the other NDI® tools. Third, you can add an OBS filter to any source or scene in OBS to make that individual source/scene an NDI® output. OBS can be used in this way to output complex scenes with multiple sources via NDI.

Open Broadcaster Software - NDI Options



NDI Output Settings
(Found in Tools Menu)



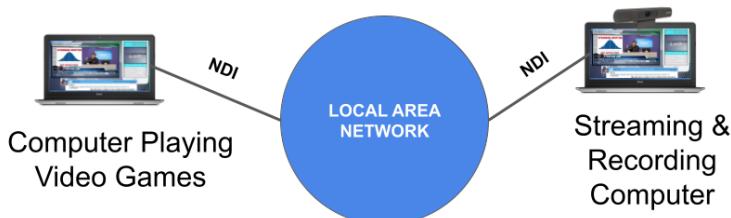
NDI Input Options
(Found in Sources)

NDI® settings inside OBS.

Example: Using OBS as an NDI® output

One example of using an NDI® output with OBS is a dual computer set-up. Many people have multiple computers and they want to stream, record, and play videogames at the same time. In many cases, one computer is not powerful enough to play computer games and live stream at the same time. So it's possible to have one computer for playing video games, and another for live streaming and recording the content.

OBS Use Case #1

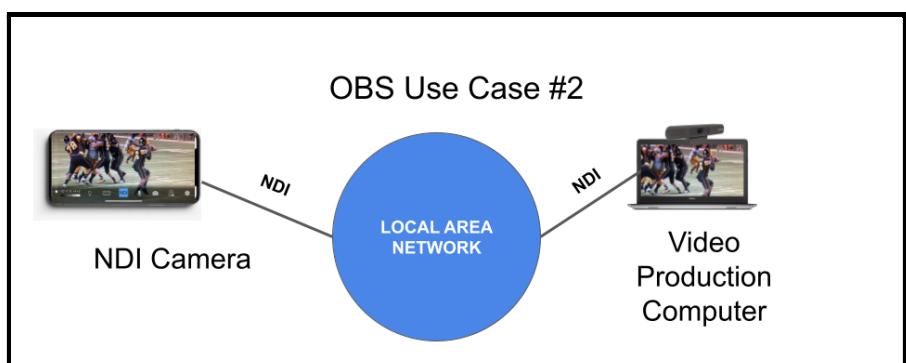


Two computers connected with NDI®.

Connecting two computers with OBS is very easy with NDI®. One computer is set up to output NDI® and the other simply uses NDI® as an input source. As long as both computers are on the same local area network (LAN), the video should be crystal clear and reliable with minimal latency. Another popular use of OBS is to output the production to another computer as a display. In this way, you can use all the tools in OBS to create a dynamic presentation with live video and data sources. The entire production can run on a Mac, PC, or Linux computer and then distributed across the network to another computer where you want the video to be displayed.

Example: Using NDI® as an input

Perhaps the most popular way to use NDI® as an input in OBS is with a smartphone. NDI® offers two smartphone applications which can be used to send video in two different ways. NDI® Camera turns a smartphone into an NDI® camera. NDI® Capture captures the screen of a smartphone and makes the video available as NDI®. NDI® Capture is ideal for mobile video gaming or presentations that happen on a smartphone. NDI® Camera is great for sharing live camera video with OBS over a LAN.



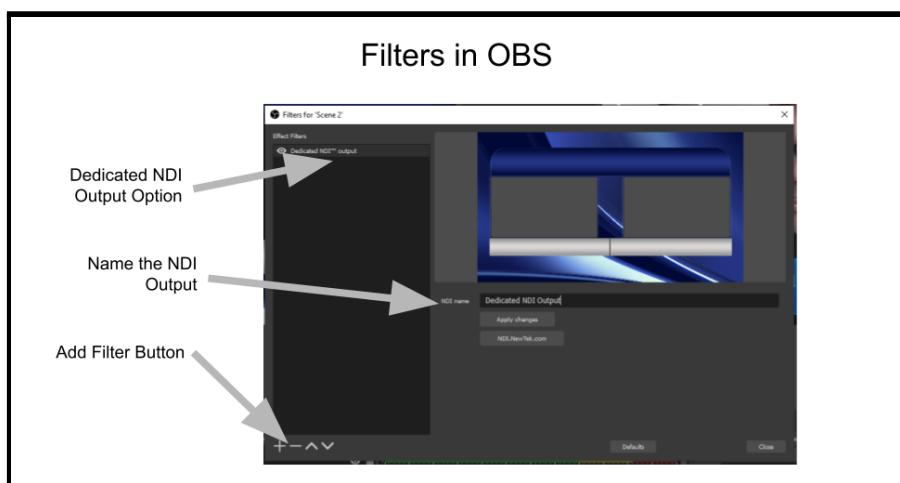
NDI® Camera used with a video production computer running OBS.

There are multiple benefits to using an NDI® Camera instead of a regular webcam. First of all, smartphones are popular and they feature some of the best camera technology available to consumers. Secondly, the NDI® Camera solution uses WiFi and doesn't take up a USB port. Therefore, NDI® Camera can be used untethered from the computer it's used with to provide new and interesting viewpoints.

Mobile phones can be used to send screen captures with NDI® Capture too. While mobile phones are great for playing video games and making presentations, they can be clumsy when used with multimedia applications such as live streaming and video production. Therefore, NDI® provides an easy way to incorporate mobile phone connectivity with larger live video productions.

Example: Using NDI® filters

OBS is organized into scenes which are used to create various layouts in an organized manner. Each scene is made up of sources which are multimedia elements that might include an image, text, a video, or an NDI® source among other options. In this way, OBS users can create dynamic scenes with an unlimited number of sources and switch between them as their live video productions are being streamed or recorded.



Filters area of OBS.

You can apply filters to an entire scene or an individual source. They can be used to sharpen a source, change the color, apply a color key and much more. Once the NDI® plugin is installed with OBS, a new filter called “**Dedicated NDI® Output**” becomes available as a filter. This is a great way to create a dedicated NDI® output beyond the **Program Output** of the software. You can add a filter to any source or scene by right clicking the scene and choosing the **Filters** option. Once the filter has been added, you can name your NDI® output. This is the name that will be discoverable by other NDI® solutions on your LAN.

OBS is a powerful tool for NDI® users of any experience level. From an accessibility standpoint, OBS is free and it supports all major computer systems. While OBS is not necessarily a tool found in high-end television studios, it's the world's most popular video production software. You should consider using OBS to create dynamic NDI® content.

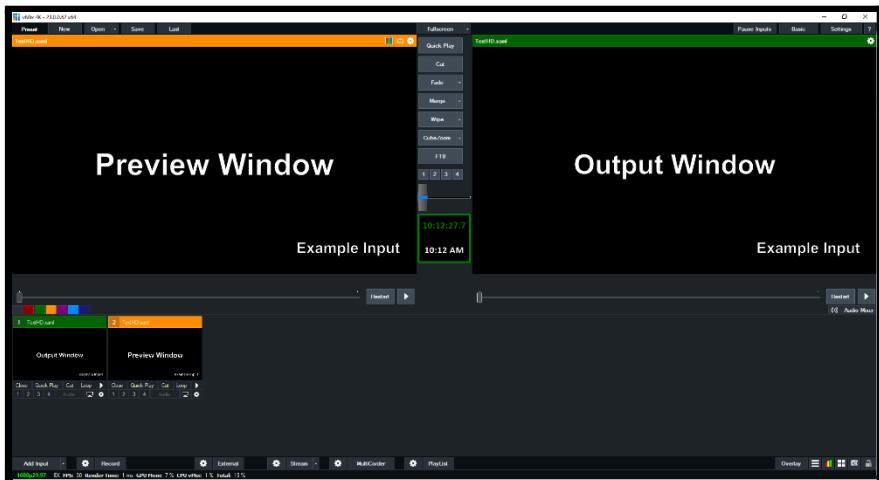
Key Takeaways:

1. OBS is a completely free video production that continues to improve with each release.
2. OBS is open source and the project is supported by a large community of developers.
3. There is an NDI® plugin for OBS which provides NDI® connectivity for OBS.
4. NDI® can be used as a video input or output with OBS.
5. Because OBS is free, it's a great application to produce NDI®-enabled video content for use with NDI® tools such as Studio Monitor.

Chapter 8

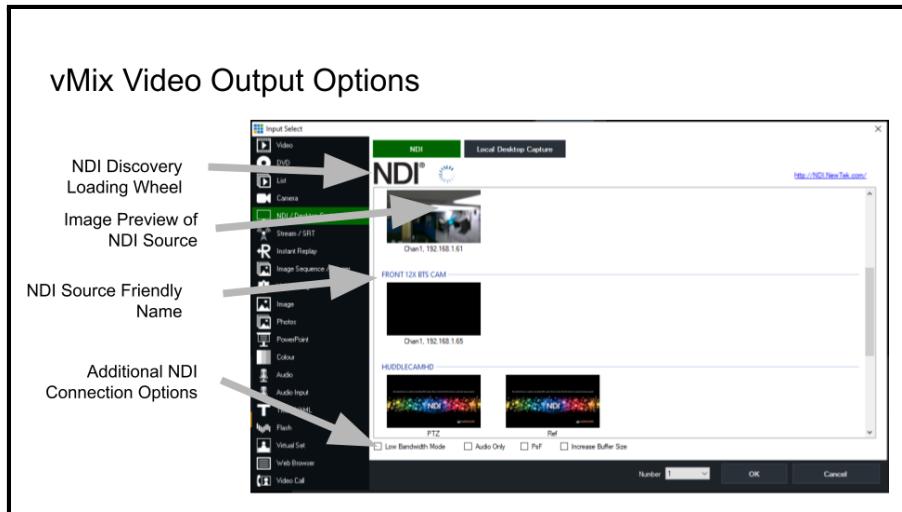
THE vMIX EXAMPLE

Live video production software vMix was designed for use on Windows computers. It was also one of the first video production software solutions to announce NDI® support in 2016. Over the years, vMix has become one of the most popular video production solutions. Therefore, reviewing the NDI® implementation available in vMix is a good ideal way to see the multitude of options available.



Interface for vMix with the standard Preview and Output windows.

NDI® has opened up a new world of possibilities for vMix users which, in turn, has created a customer feedback loop that has led to many notable improvements. And vMix supports both NDI® input and output functionality with a variety of options.



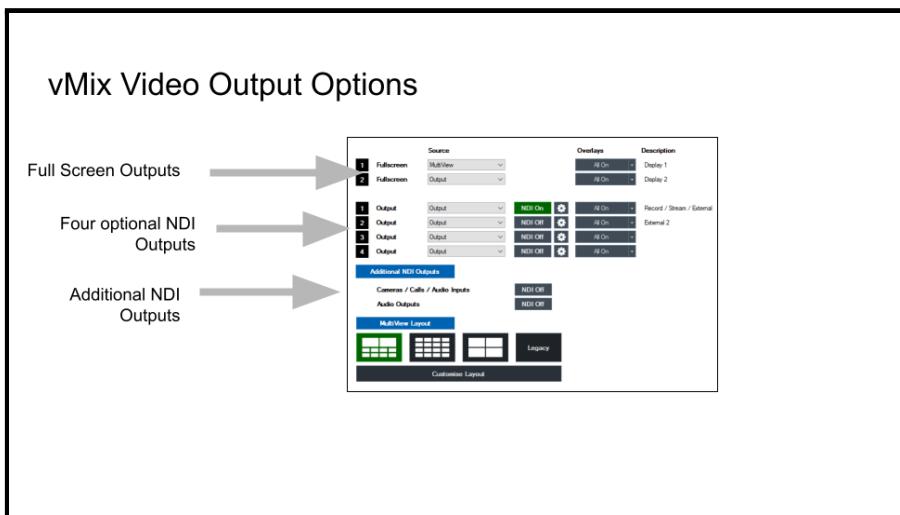
The Input Select area of vMix open to the NDI® / Desktop Capture area.

Connecting to the NDI® inputs is fairly simple with vMix. When you open vMix, click the **Add Input** option and select the **NDI®/Desktop Capture** tab to view available NDI® sources on your network. A small loading animation will cycle next to the **NDI®** logo to let you know that vMix is searching for NDI® sources that are available on your local area network (LAN).

The tool will display NDI® sources with a friendly name, an image, and an IP address when available. One area of vMix many users appreciate is the little preview windows that makes it easy to switch between sources. Below the list of available NDI® sources, you can choose to connect with **Low Bandwidth Mode**, **Audio Only**, Progressive Segmented Frame (**PsF**), or **Increase Buffer Size**. **Low Bandwidth Mode** is a great option if you are having bandwidth issues on your network. **Audio Only** mode will allow you to connect to the NDI® source without video. The **PsF** option is a progressive video format like 1080p29.97 or 1080p30. Finally, **Increase Buffer Size** is ideal for scenarios where latency is not an issue.

Once you have connected to an NDI® source, vMix added a feature to right click on that NDI® source to choose any of these options on the fly. In fact, when you right click on an NDI® source, you will see a list

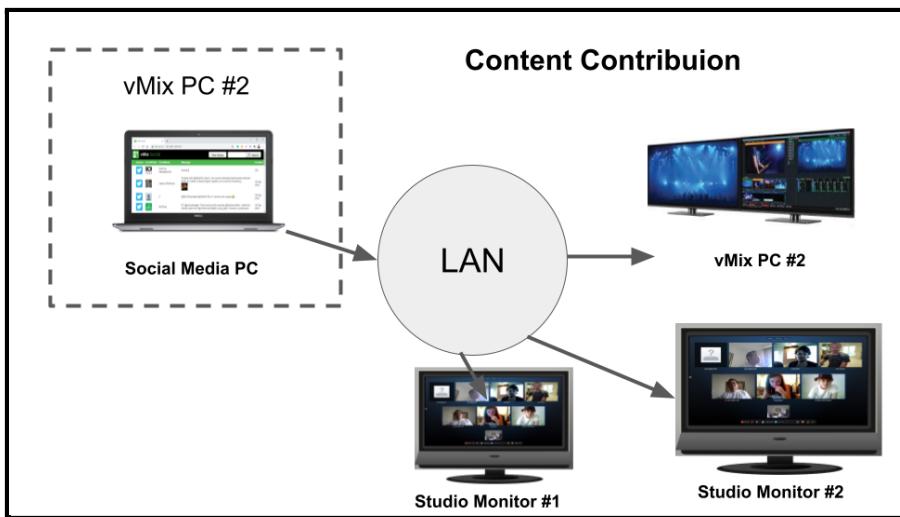
of other NDI® sources on your network. This helps you swap between NDI® sources and conserve bandwidth and processing power.



The NDI® output options using vMix.

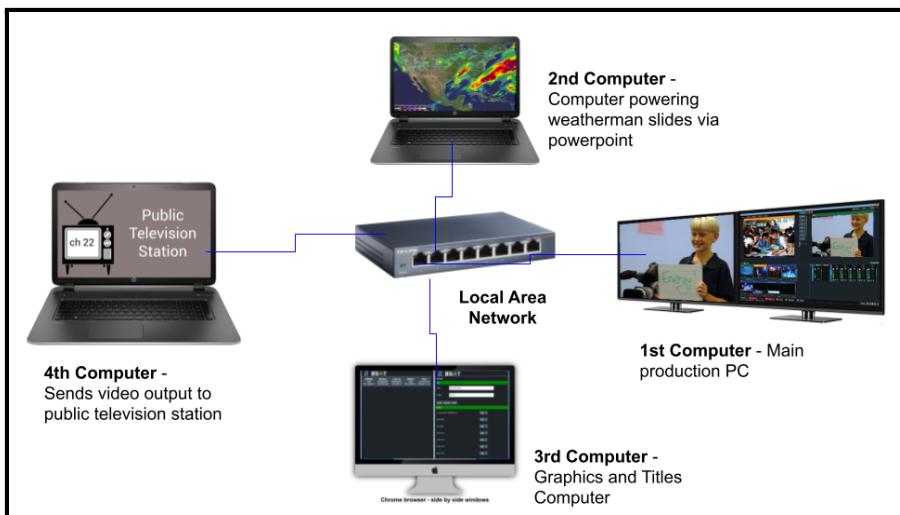
The vMix tool is capable of supporting many NDI® outputs. You can configure the NDI® output options in the **Settings** area under **Outputs**. Here you can set up four unique NDI® outputs and configure each. In fact, each NDI® output is configurable so that you can choose between settings for audio, video resolution, Secure Reliable Transport (SRT), latency, and even encoding options where available. Below the four main NDI® outputs you also have an option to turn all cameras, calls, and audio inputs into NDI® outputs. This is ideal if you want your vMix system to be able to share all of its camera sources; for example, with another NDI®-compatible system.

Simple Use Case:



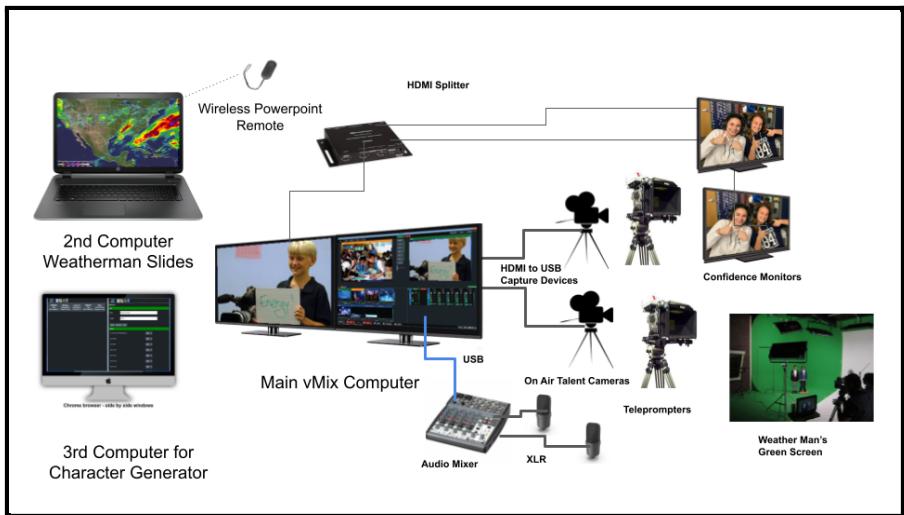
A local area network with two computers running vMix. On the same network, two computers are also running Studio Monitor.

The StreamGeeks use video content contribution from a second computer using vMix. In the diagram above, you can see that the StreamGeeks studio has two computers running vMix and two computers with Studio Monitor. One vMix computer is the main video production machine, and the second vMix computer is used to contribute social media content. There are many scenarios where using a second or third computer with vMix is useful. Another interesting use case comes from the Griswold Elementary School broadcast club. This use case along with a handful of other interesting educational examples comes from the *Accelerated Broadcast Club Curriculum*.



A local area network used for a school announcements show.

In the example above, you can see a four-computer set-up that broadcasts the morning announcements at an elementary level school. The first main production computer runs vMix. The second computer runs NDI® Screen Capture which sends PowerPoint slides that display the weather in the main vMix computer. A third computer is used to connect directly to the vMix remote controller available via an IP address. This computer triggers overlays and graphics. Using the vMix remote control connection, an operator can update and change the information in titles that appear in the main production computer. Finally, a fourth computer runs with an additional copy of vMix in order to receive the main production computer's output and connects it to the local public television system.



The four-computer production system in more detail.

As you can see from the diagram above, NDI® makes a small video production system very powerful. In addition, vMix already supports many IP connectivity features such as remote control which make NDI® integration very efficient. Each video production software system has a slightly different NDI® implementation. You have now seen both OBS and vMix which will give you a good sense of what to expect in a variety of other software solutions.

Key Takeaways:

1. The vMix tool is one of the most popular paid live streaming software solutions.
2. It has maintained industry-leading support for NDI®.
3. You can use vMix to create NDI® video outputs in a variety of convenient formats.

Chapter 9

SIMPLIFYING VIDEO WITH IP

While the possibilities with NDI® are endless, for most users, the most significant advantage of the protocol is simplifying connections and workflow. With the multitude of devices and software packages available for broadcast video, putting together and operating a video production solution can be overwhelming. Getting a system to work well involves understanding the benefits and limitations of various cabling options, ensuring the compatibility of devices, and the production computer or switcher has the capacity to provide the end result your project requires.

NDI® can radically simplify, not only set-up but ongoing use. Imagine every device and piece of software sending and receiving video data using the same format and protocol. You will no longer need to rewire cables to change a configuration since everything will run over ethernet cabling as a standard. In fact, cameras and other sources can be added without a direct run to the hardware or software switcher. A short cable to the closest ethernet connection enables access to all computers on the network.

PTZ Camera Traditional

Cable (100')	Weight	Cost
SDI	2.5 lbs	\$60
RS-232	2.5 lbs	\$50
Power Supply	.6 lbs	
Camera Weight	3 lbs	

Total Weight: 8.6 lbs
Cabling Cost: \$110

PTZ Camera NDI

Cable (100')	Weight	Cost
Ethernet	2.7 lbs	\$15
Camera Weight	3 lbs	

Total Weight: 5.7 lbs
Cabling Cost: \$15

The weights of cables that are included with a PTZ camera.

While traditionally, a PTZ camera requires an SDI cable, a control cable, and a power supply, using NDI®, a single ethernet cable will provide video, control, and power. If you are running multiple cameras with 100' of cabling, you will save roughly three pounds of weight per camera. This is a big deal and potential cost-savings for those who set up onsite live streaming systems on a regular basis.

With NDI®, connecting a camera, computer, or another device anywhere on your LAN makes the gear available to another device anywhere on the same LAN. This has opened up possibilities for those who are new to video technology. The next generation of video producers will expect this type of connectivity. In short, there's no turning back; IP video is here to stay.

Another benefit of NDI® is scalability. It is frustrating when you need to add another camera or other device and find that there are no more available inputs on your switcher. Traditional capture cards require USB or Thunderbolt ports on your computer which are always limited. Using IP video means that the number of sources you can use is only limited by your bandwidth and the number of open ports on your network. Fortunately, even if your ethernet LAN ports are full, it is inexpensive and straightforward to add an additional switch to the network.

If the space you are using already has a LAN that meets NDI® standards as referenced in Chapter 6, you can connect sources and be up and running in minutes. In addition to sources being available for production, streaming, and recording software, NDI® can facilitate the routing of any available video to video displays, including control room monitors, confidence monitors, and video displays for an audience or public viewing. Video for IP using NDI® can even send any NDI® source, including your production switcher, to a virtual webcam input allowing new flexibility in popular video conferencing software platforms like Microsoft Teams or Zoom.

In conclusion, the main benefit of NDI® is ease of use and simplicity of integration. For those who have been trained in traditional video switching hardware, NDI® is a paradigm shift. For those who are just getting started with live streaming and video production, NDI® is a solution that you will learn that you cannot live without. It's not unusual for new technologies to quickly leapfrog over old standards. For these reasons, NDI® has become the standard for network video on a LAN.

Key Takeaways:

1. NDI® will make your video projects more efficient.
2. IP video represents a paradigm shift and its benefits will pave the way for even more scalable video projects in the future.

Chapter 10

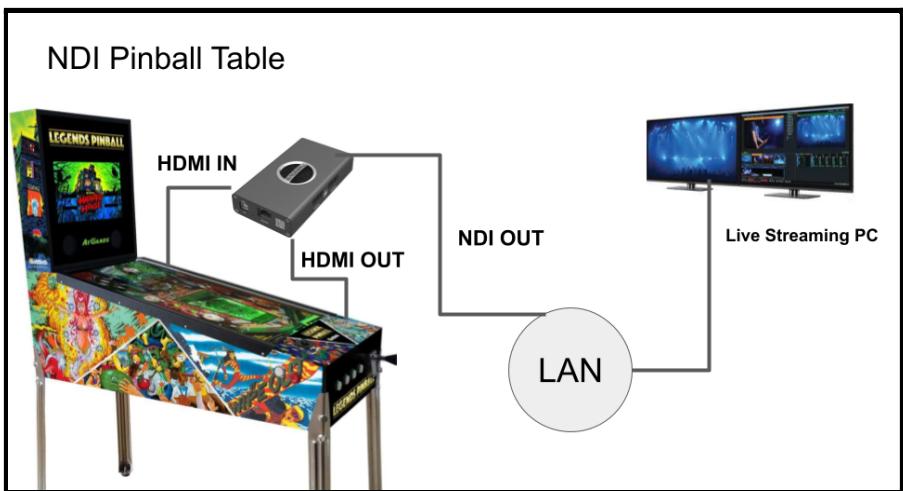
USING NDI® VIDEO CAMERAS

NDI® makes it easy to add video cameras to your production. NDI® is now available as a standard output for many cameras and there are ways to integrate existing cameras into a modern NDI® workflow as well. Here are five options for connecting a video camera to an NDI® network:

- **NDI® Cameras** – NDI® cameras connect directly to the LAN via an ethernet cable to output video and audio on the network. NDI® cameras are available with NDI® HB and NDI|HX® formats.
- **NDI® Webcams** – Webcams with NDI® built-in have an ethernet connection instead of a USB port. HuddleCamHD offers a 4K NDI® webcam that plugs into the LAN and uses NDI® Webcam Input to interface with video communications software.
- **Mobile Cameras over WiFi** – Any smartphone can be connected to an NDI® network via a WiFi router. There are two different NDI® applications available for both iOS and Android.
- **Cameras Attached to a Computer** – This mainly refers to internal or external webcams but could include any camera connected to a computer on the network. Any USB-connected webcams can be used with software like NDI® Screen Capture, or a video production software like OBS as an NDI® source.
- **Cameras Connected to the NDI® Network that Use a Convertor Box** – Traditional HDMI and SDI cameras can be connected to an NDI® capture card to make the camera's video available via NDI®. Capture cards connect HDMI or SDI cameras into USB for use on a computer. These cameras can then be treated like webcams in the sense that they are used with NDI® Screen Capture.

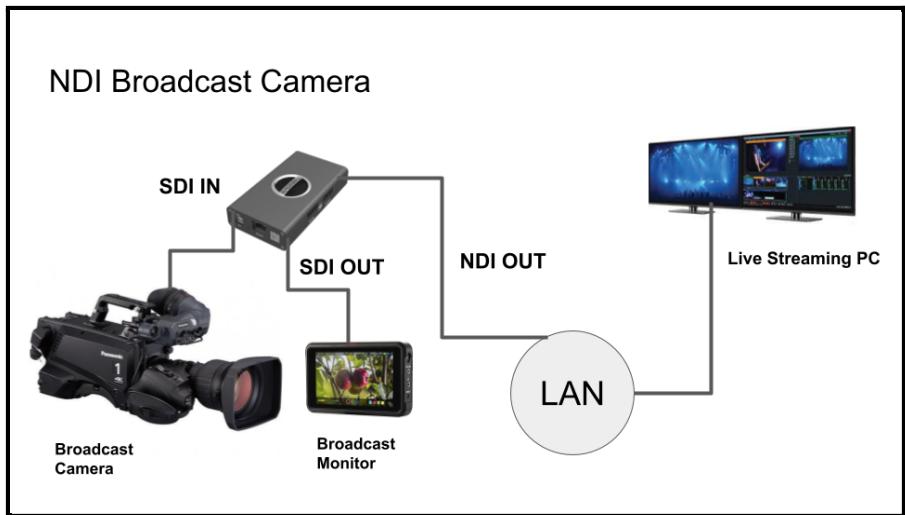
Modern digital video cameras tend to feature either HDMI or SDI outputs and some camera models feature both. While NDI® is becoming a more common feature on PTZ cameras, other camcorders and broadcast cameras still require a capture device to connect via NDI®. You can convert any SDI or HDMI signal into NDI® with an NDI® encoder.

For HDMI cameras, there are several options from Magewell, NewTek, and other manufacturers to capture HDMI and convert the signal to NDI®. All you need to do is plug the camera's HDMI output into the converter, and plug the converter into the network. Most of these NDI® encoders use a Power Over Ethernet (PoE) switch. If you do not have a PoE switch, most NDI® encoders can also be powered via a USB connection.



A Magewell Pro Convert with an HDMI loop-through.

An example using an NDI® encoder from Magewell appears above. In the StreamGeeks studio, there is a digital pinball table with an LCD television for the pinball playing surface. The Magewell Pro Convert loops in and out the existing HDMI connections so that the computer and LCD remain connected. The Pro Covert also outputs an NDI® signal with low latency. The NDI® output is then used with any NDI®- compatible software for live streaming.

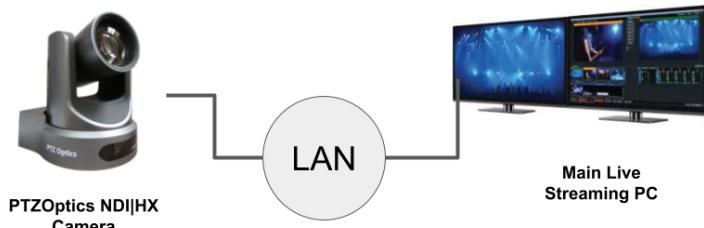


NDI® encoder with a broadcast camera.

Another popular use for NDI® encoders is for traditional cameras that are not yet NDI®-capable. In the diagram above you see the SDI Pro Convert from Magewell sitting in between a broadcast camera and the local preview monitor used by the camera operator. Many traditional video cameras are now being upgraded to fit into modern IP workflows using NDI® encoders like this one.

With any NDI® encoder or camera with NDI® builtin, you can access settings for network-connected devices via an administrative panel using a web browser. You can type the device's IP address into any web-browser connected to the LAN network. The available settings vary by device, with some allowing users to adjust the brightness, contrast, saturation, and hue of the actual camera or incoming video feed.

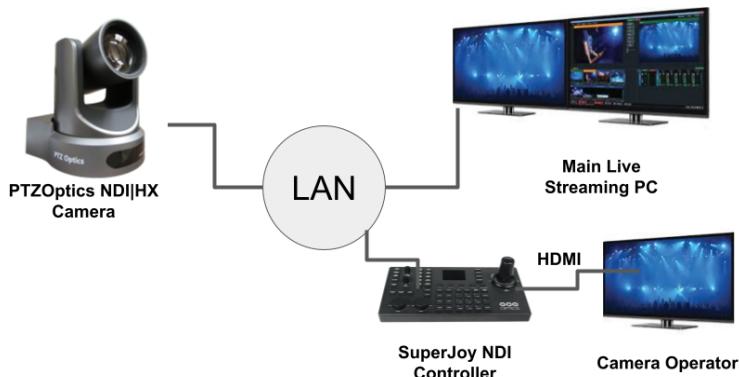
NDI PTZ Camera



A PTZOptics NDI® camera connected to a live streaming computer over the network.

One of the most effective ways to start using NDI® is to use an NDI®-enabled device. You can easily expand your existing NDI® production workflow through the use of NDI®-enabled devices and PTZ (pan, tilt, zoom) cameras are particularly useful for a variety of reasons. Starting with NDI® 3.0, NDI® has supported PTZ camera control in Studio Monitor. Using a power over ethernet (PoE) switch, every aspect of the PTZ camera, including power, runs with a single ethernet cable. While many PTZ cameras already have audio/video and control over IP builtin, NDI® makes the connection more stable and reliable while drastically reducing latency.

NDI PTZ Camera



A PTZOptics NDI® camera connects to the local area network. The camera also connects to a live streaming computer and an NDI® joystick controller.

PTZ cameras with built-in NDI® can add broadcast-quality video with the added benefit of robotic controls to NDI®-enabled software and hardware systems. PTZ stands for “pan, tilt, and zoom” which are camera operations that can be controlled from anywhere on the network. PTZ camera controls offer producers the ability to quickly control cameras. In many cases, producers have access to built-in controls in the video production software they are already using such as OBS, Livestream Studio, Wirecast, or vMix. Many PTZ cameras are available with full 1080p video resolution and frame rates up to 60fps. The PTZOptics 30X-SDI, for example, includes a 30x optical zoom that is capable of zooming in on the head and shoulders of a person on-stage from 75' (32 meters) away. PTZ cameras are easily integrated into NDI® video production workflows.

With NDI® builtin, PTZ cameras can be connected in minutes for unparalleled quality and control. In the past, PTZ cameras required one cable for audio, another video, one for control, and another for power. With NDI®, PTZ cameras, audio, video, control, and power can be handled through a single ethernet cable connected to a PoE switch. This makes installation much more straightforward and only requires enough cable length to make it to the nearest network switch.



The SuperJoy NDI® camera controller.

As NDI® becomes more popular, the standard is now being used in joystick controllers. The PTZOptics SuperJoy above is a controller designed to work with any NDI® camera. While the SuperJoy supports multiple network control methods including VISCA over IP, NDI® is designed for ease of use.

Anyone looking to add more cameras to their production will find that using NDI® to send video over the network is a highly flexible option. With the latest broadcast-quality PTZ cameras offering built-in NDI®, remote-controlled cameras can be added using one cable. Currently, there is only one webcam that comes with NDI® built-in. Built-in webcams on computers can easily become video sources for a production. Even legacy equipment with HDMI and SDI outputs can become part of the network using an encoder. If you have a camera, you can connect it to your network to use with NDI®.

If you currently have PTZ cameras without NDI®, you still have some options to easily add them to your NDI® network. One option is to upgrade the firmware. Some PTZ cameras can receive firmware upgrades to make them fully NDI®-capable. If that is not possible, there are also converters available that can turn the output from the PTZ camera into an NDI® source. Some of these, with a suitable cable, can allow the PTZ controls to be accessed via the NDI®

network. In conclusion, PTZ cameras with NDI® built in are game changers. These cameras have a long list of benefits which include discoverability, optimized video, tally support and much more.

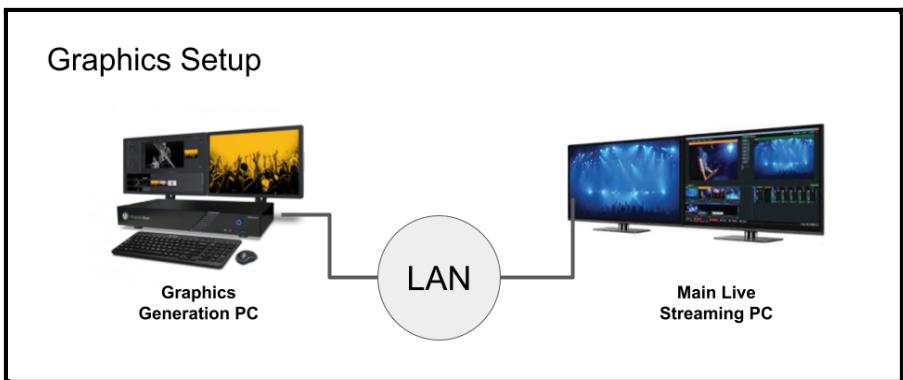
Key Takeaways:

1. Many cameras now come with NDI® built in.
2. Cameras that do not support NDI® natively can be used with an NDI® encoder to output NDI® video on your network.
3. NDI® allows you to gain additional video camera features like network discoverability and PTZ camera controls.
4. PTZ cameras are ideal NDI®-enabled devices because they provide video and control over a single ethernet connection.
5. NDI®-enabled PTZ cameras are easily integrated into available NDI® tools to make video productions easier to set up.

Chapter 11

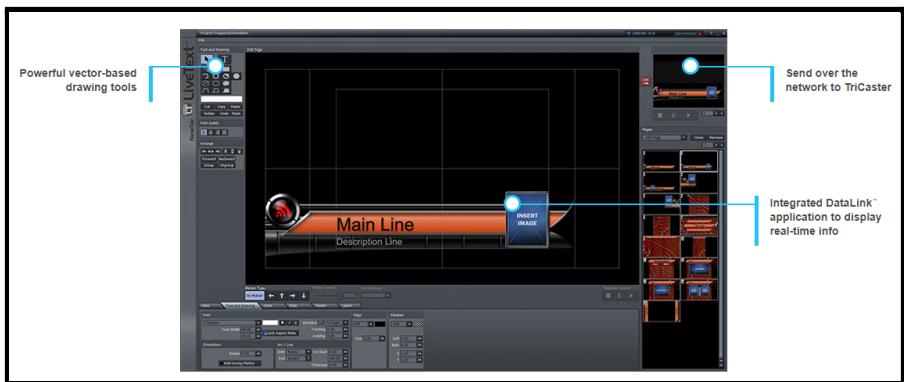
GRAPHICS GENERATION USING NDI®

While most production software packages and hardware switchers have some built-in graphics generation capabilities, many productions require even more power and control. In professional, fast-moving environments, graphics creation often happens at a dedicated workstation. In some cases, multiple workstations are used to keep up with on-the-fly graphics design and editing.



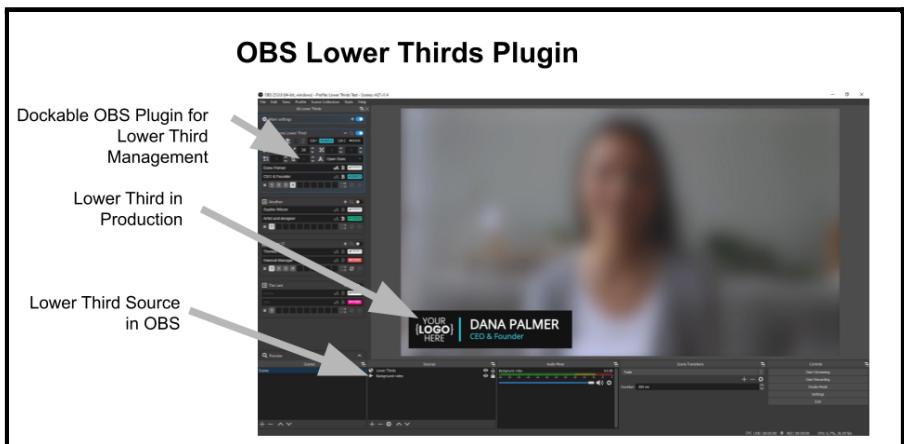
Two computers connected with NDI® in a live production environment.

With NDI®, graphics and titles can be generated anywhere on the network and used immediately as a production source. Using an additional computer for graphics and title generation allows small teams to collaborate in a live production environment. It also distributes the workload away from the technical director or switcher operator who often has more tasks than they can handle on their own. NDI® makes it easy for a dedicated graphics operator to create and manage graphics so they are ready to go when needed by a producer on the same network.



NewTek LiveText allows a computer to output broadcast graphics to another computer using NDI®.

NewTek offers a standalone, NDI®-compatible program called NewTek Live Text, which turns any PC into a standalone graphics and titling workstation. Titles and graphics can be built on the fly and sent to another computer running OBS, or another NDI®-compatible production switcher in real-time. Users can quickly add custom titles, graphics, scores, stats, and clocks.



Animated lower thirds plugin for OBS.

Open Broadcaster Software (OBS) offers a free animated lower thirds plugin to generate graphics. To use NDI® with OBS, all that's required is a free NDI® plugin. The NDI® plugin for OBS allows you

to output the entire production of OBS as an NDI® source or an individual source.

NDI® also offers an Adobe Creative Cloud plugin that works with Adobe Premiere and After Effects. This allows graphic designers to run animated titles, motion graphics, looping effects, and more in a live production environment. Other popular NDI®-enabled presentation software includes ProPresenter and Easy Worship. ProPresenter makes presentations look more professional with masks, overlays, slides, and announcements but generally requires a dedicated operator. Using an NDI® video output from ProPresenter, the operator can easily send the graphics to a livestream producer on another computer on the network. NDI® video can be used with an alpha channel which provides users with a transparent layer of video. Video with an alpha channel can easily be layered on top of camera sources for example to create a seamless integration for video productions.

In addition to NewTek's offerings, there are several software packages dedicated to graphics generation that are NDI®-compatible. From simple titles to professional broadcast news options, a variety of software can add a higher level of graphics to your NDI® production network. Some of the options are from RT Software, Nexus Celio, Panamation, and NewBlueFX. For a collection of official NDI® products, go to: ndi.tv/marketplace.

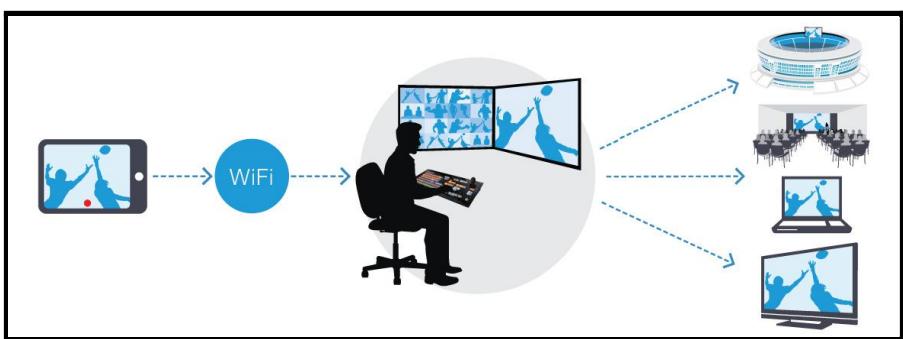
Key Takeaways:

1. As your video productions grow more sophisticated, working with graphics software is often necessary.
2. NDI® is an ideal way to connect a computer running graphics software to another system that's used for live streaming or video production.

Chapter 12

WIRELESS NDI® & SMARTPHONES

Imagine being able to add more cameras to your production without having to run any cables. By using a smartphone with one of the NDI® apps, you can capture video and audio from any compatible iOS or Android device in resolutions up to 4K. As long as the device can connect via WiFi to your LAN network, it can instantly be added as a source for your switcher or viewed with Studio Monitor.



A basic NDI® camera workflow with WiFi.

This is a great way to cover concerts, sporting events, or other productions where additional angles and close-up shots are critical. Thanks to the ability to use both forward and rear-facing cameras, mobile phones and tablets can be used for more interactive exchanges with hosts and camera operators. This option also enables you to get video shots from places where cables would be unmanageable.

What about extending your network entirely across a football field or in-between buildings? The WirelessCable from PTZOptics is a networking solution that can extend your NDI® network up to 1,300 feet or 400 meters. The WirelessCable allows you to connect one network to another just like an ethernet cable would through a

professional Wireless Access Point (WAP) system. In this way, one large NDI® network connects wirelessly for use with cameras and other devices.

Getting Started with Mobile Cameras Over WiFi

Download and install the NDI|HX® Camera application from the Google Play Store or the Apple App Store. Connect to your LAN via WiFi, and open the application. Compatible computers and devices will automatically discover the output from your smartphone on the network. There are ultra, high, medium, and low bandwidth modes to deal with any bandwidth limitations.

The NDI|HX® Camera Application works with both front-facing and rear-facing cameras. The app features camera tools like pinch to zoom and an optional grid overlay for mobile camera operators. It also features autofocus, autofocus lock, tap to focus, auto exposure, exposure lock, and manual exposure modes. There is also a connection notification and tally display, so operators will know when they are live. Both audio and video can be muted with one touch.

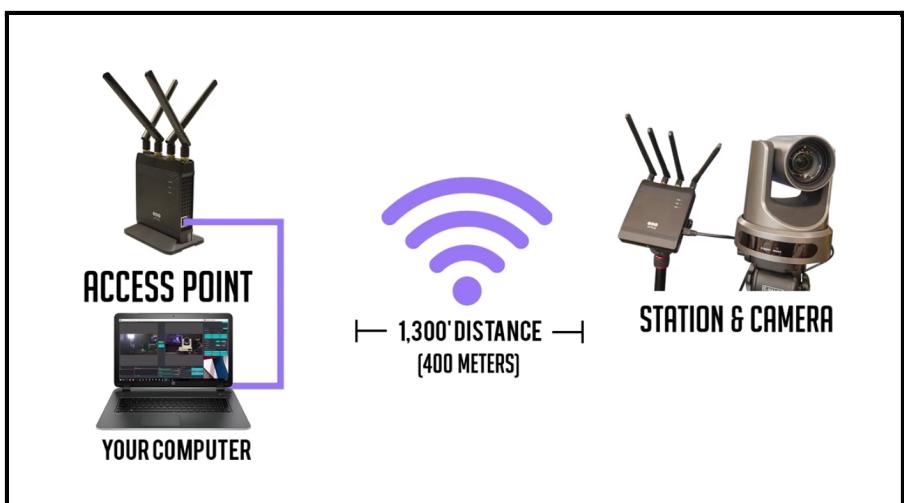
Pro Tip: If you are using a professional audio system in a studio space for example, you will likely want to mute the audio coming through the phone. It is possible to create an audio loop with two microphone sources that are slightly different.

With the NDI|HX® Camera and the NDI® Webcam Capture tool, any compatible phone or tablet can be used as a webcam over the NDI® network. Therefore, you can use your smartphone as a webcam with software like Zoom. Overall, video users are now able to quickly add more cameras to any production without the need for additional cables.

Working with Wireless NDI®

Working with wireless NDI® video sources can require some networking knowledge. The WirelessCable is a device that was designed to simplify long distance wireless video transmission for use with NDI®. Using the WirelessCable, setting up wireless NDI® networks is

actually plug and play. This is because WirelessCable devices create a low latency, point to point connection between networking devices. In this way, the WirelessCable can be used to connect a single device like a PTZ camera or an entire network using a network switch. Unlike traditional wireless HDMI or SDI technology, NDI® can be used to wirelessly control a PTZ camera, or change the output of a device. Using wireless technology with NDI® makes communication bi-directional.



Wireless connectivity for NDI® using the WirelessCable.

It is also possible to use networking equipment to provide wireless NDI® connectivity. If you plan to use your own Wireless Access Points (WAPs), it's best to use a fully managed networking system with static IP addresses assigned for all networking hardware. If any part of the network is not managed, or manually configured to work in unison with the rest of the network, there can be enormous incompatibilities in communication between the networking equipment. Some of the most important settings have to do with multicast and mDNS routing.

Matthew Davis, the lead engineer at PTZOptics, who created the WirelessCable also wrote a guide for Ubiquiti networking equipment available in the PTZOptics Knowledgebase: (help.ptzoptics.com). Here are some notes for your consideration.

Symptoms of a misconfigured network...

Multicast DNS (mDNS)

- When you use a discovery or configuration tool and it is unable to locate your device connected to the same network
- When you use a discovery or configuration tool and it randomly finds devices that also disappear randomly.

Multicast

- When connecting to a multicast source, your video appears to “smear” or “bleed”.
- When connecting to a multicast source and you have a successful connection, but receive no content.
- When connecting to a multicast source and your network crashes.
- When connecting to a multicast source and your network slows to an unusable speed.

Overview of issue(s) and steps

- When you have more than one network switch being used in a situation with equipment and applications that use mDNS for discovery, the switches need to be told which switch will be the “holder” of mDNS discovery tables.
- When the IGMP snooping querier is enabled, it periodically sends queries that trigger IGMP response messages from hosts that are requesting to receive IP multicast traffic.

- The next step is enabling IGMP and possibly, depending on your exact requirements, enabling or disabling multicast traffic via wireless access points.
- Multicast traffic via your WiFi network is a decision that should not be taken lightly as it is very easy to overload a wireless access point (WAP) with multicast traffic. Also not all WAPs are capable of handling multicast traffic; please refer to manufacturer documentation.

You can learn more about setting up a wireless network for NDI® by referencing “**Setting up a Ubiquiti Network for PTZOptics & NDI®**”: help.ptzoptics.com.

The process of properly configuring networking equipment for use with wireless NDI® connectivity can get technical. NDI® does not offer networking equipment directly, and each networking equipment manufacturer offers different products. Review settings including Internet Group Management Protocol (IGMP) snooping, IGMPv3 or greater, LAN to WiFi Multicast traffic settings, and mDNS configurations.

In conclusion, it’s worth testing your existing WiFi hardware with a smartphone app or wirelessly connected computer with NDI®. If the video works smoothly, you may have a working system that does not need to be configured. If you are having issues using NDI® over WiFi, you may want to consider looking into a WirelessCable system. Finally, if you want to use your own wireless network, it more than likely will require some configuration.

Key Takeaways:

1. Most modern smartphones can be used to send video wirelessly into an NDI®-capable system over WiFi.
2. Setting up a network to handle wirelessly transmitted video

THE UNOFFICIAL GUIDE TO NDI®

- smoothly can require some network optimization.
3. The WirelessCable system has been built to provide wireless video connectivity for NDI® networks.

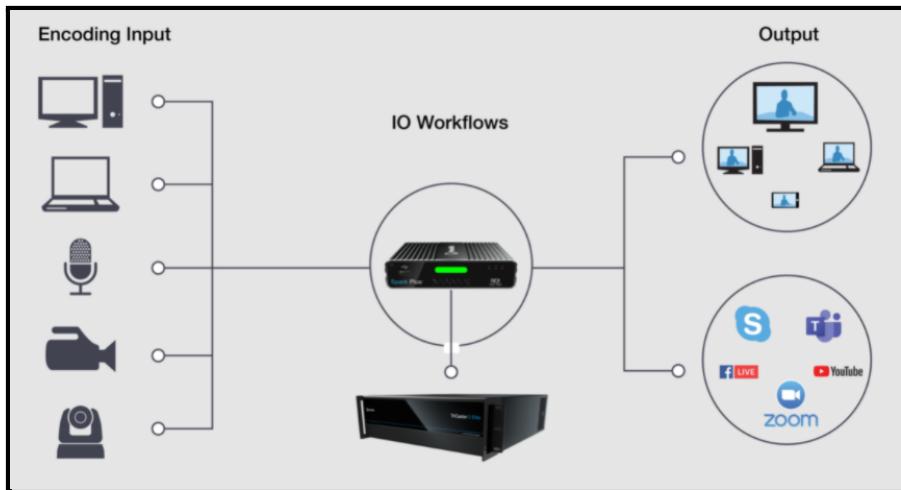
Chapter 13

NDI®-POWERED VIDEO DISPLAYS

Once you start using NDI®, routing audiovisual sources bi-directionally across a network becomes very powerful. Initially, most people think about NDI® as a way to route inputs to a hardware or software switcher. But in this chapter, you will learn about sending sources to video displays and managing that content on your network. An organization may want to display one particular input, such as a camera or the live program output from a switcher on a display set-up in a lobby. There may be another display on set that is being used to display comments from social media or other graphics. Either way, it is quick and easy to set up and manage NDI®-connected video displays to show different sources on your network.

Studio Monitor is perhaps the most important application for displaying NDI® content on a screen. Studio Monitor can essentially turn any computer into a decoder. A decoder is a device that takes a video stream like NDI® and decodes it to display via HDMI or SDI on a monitor. Many NDI® capture devices can be used interchangeably as a decoder or an encoder. An encoder is used to turn an HDMI video signal into NDI® and a decoder does just the opposite. An NDI® decoder is generally easier to use and more reliable than a regular computer running Studio Monitor. NDI® capture devices are available from NewTek, Magewell, and other manufacturers. There are endless numbers of possible applications that can be easily changed depending on the need.

NewTek's Spark appliances offer bi-directional conversion which means they can both convert to act as an encoder or decoder. Different models can convert to and from 4K HDMI, 3G-SDI, and even 12G-SDI.



Inputs and outputs used over the network.

NDI® powered video displays can be used to display the main program feed for a broadcast or live stream. This is ideal for events with a live audience. NDI® powered video displays are also efficient for overflow areas or lobbies to offer people a view of the live event in common areas. NDI® powered video displays are great for spectators, gaming competitions, and demos because of the low latency features on NDI®.

Displays connected with NDI® sources can also be used by digital signage applications for static or video announcements, promotions, and event information. NDI® is also effective if you want to provide content for video walls. VuWall, a leader in video wall control systems, has built NDI® compatibility into its VuStream 150, allowing for complete control of the video wall using an ethernet connection. This dramatically reduces the amount of cabling and set-up for video wall implementations.

Applications for NDI® powered video displays are limited only by the imagination. With the ability to power a display anywhere on a local network, producers and event planners will continue to find ways to use NDI® to create more immersive and flexible video environments. In the next chapter, you will learn how easy it is to set up and control Studio Monitor, a primary tool used to display NDI® content.

Key Takeaways:

1. Powering a display with NDI® video content is an attractive option both from a content and budget perspective.
2. Studio Monitor can be used to display NDI® video content using an appropriate PC or Mac computer.

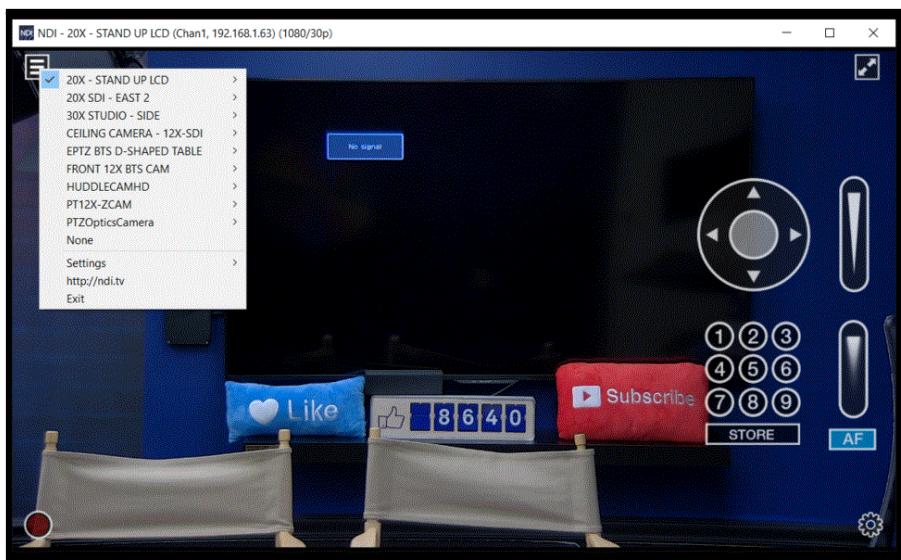
Chapter 14

STUDIO MONITOR

In this chapter, you will learn how to use Studio Monitor with NDI®. Studio Monitor is an essential tool for video production professionals already using NDI® video sources on their local area network (LAN). Studio Monitor is ideal for displaying a video output from NDI®-compatible video production software such as OBS, Wirecast, vMix, Live Streaming Studio, MimoLive and many more. The application is also ideal for camera operators who desire a low-latency video preview of their cameras located throughout the event facility, while also controlling PTZ functionality.

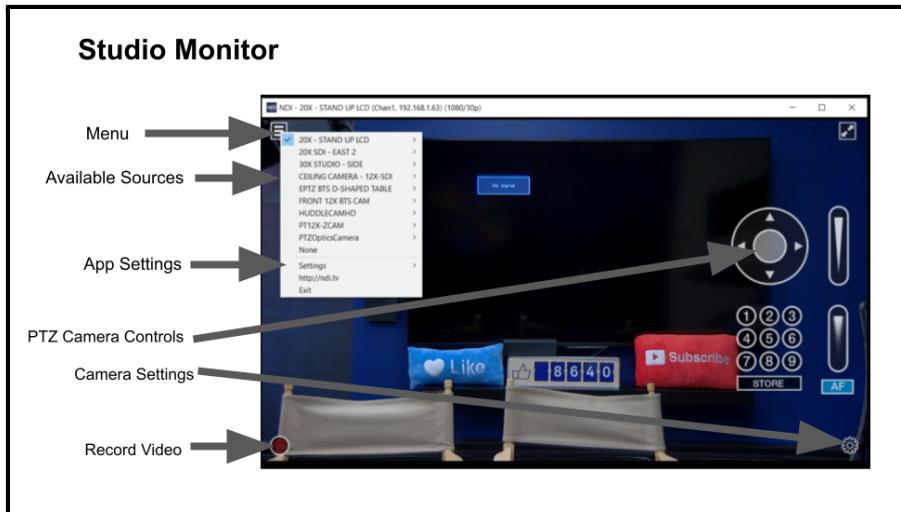
The most popular way to use Studio Monitor is to discover and view NDI® video sources on the network. Studio Monitor can be used to display NDI® sources on multiple screens connected to your computer. These screens could be set up in a lobby, on a building façade, or even on an outdoor billboard display.

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Studio Monitor with a PTZ camera

When you first open Studio Monitor you will see a menu at the top left which you can click to automatically discover a list of NDI® sources. As soon as you click one of the available sources on your network, it will fill the application with the video source. If the source is a PTZ camera, you will notice PTZ controls on the screen. These controls will be explained in the next section. Inside the menu you will see a “**Settings**” area which includes a variety of features that make Studio Monitor very useful.



Studio monitor open to show feature set.

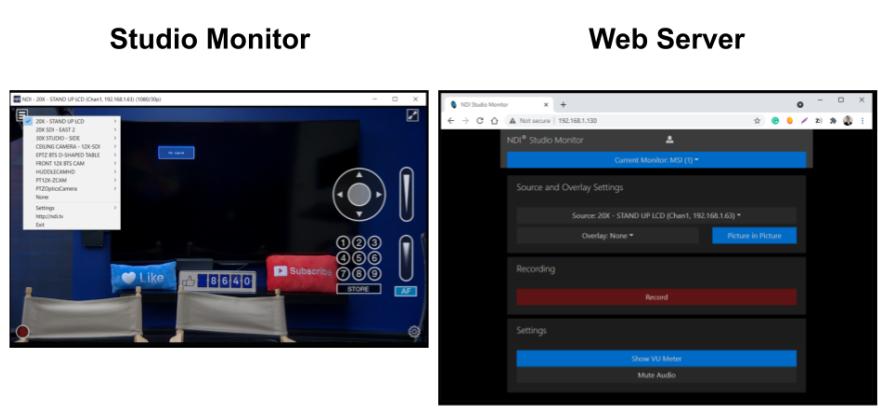
For example, there is an option to “Run at Windows Start” which is helpful for setting up a digital signage system. You can also send video to a second monitor by selecting the “New Monitor” option to open a second instance of Studio Monitor. You can, of course, run Studio Monitor in full screen mode by clicking the arrows in the top right hand corner. You will also find settings for adjusting the audio and video which may vary by device. Studio Monitor can be used to record video at any time using the red record button on the bottom left corner. There is also an area in the settings menu you can use to determine where you would like the videos to be saved on the computer’s local hard drive. If the computer is running a cloud based storage system like Dropbox or Google Drive the video files can quickly be transferred to the cloud for easy access.

Studio Monitor Startup



At startup, Studio Monitor shows a QR code and web address.

One useful feature of Studio Monitor that is easy to overlook is the web server. The web server can be accessed by scanning a QR Code that displays when Studio Monitor first turns on. Scanning this code will take you directly to the management control panel for Studio Monitor. You can also access the management area by typing in the IP address available in the settings area of Studio Monitor. The integrated web server can turn a mobile device or computer into a remote control for Studio Monitor.



Studio Monitor shown at left; Studio Monitor's web server appears on the right.

From the NDI® Studio Monitor management page, you will see just how easy it is to update and control any Studio Monitor on your network. You have the ability to switch between NDI® sources with the click of a button. You can also set up a picture and picture scenes to create new views on Studio Monitors that may be displayed around your space.



Studio Monitor used with a picture in picture setting.

Another popular use case for Studio Monitor is for remote camera operation. The picture above shows a camera operator using Studio Monitor to display a camera they are controlling. A picture in picture set-up is ideal for camera operators who may want to view the output of a video production system, but also see the PTZ camera they are controlling.

Note: In order to use Studio Monitor's PTZ camera controls, you must have an NDI®-enabled PTZ camera.



A PTZOptics NDI | HX® camera model.

It goes without saying that NDI® PTZ camera operators will control their cameras over the network. Once an NDI® camera is connected to the network, you can connect to the camera using Studio Monitor by right clicking on the screen and selecting the camera from the dropdown menu. Once connected, Studio Monitor will display PTZ controls for the camera which can be operated by a keyboard and mouse. A USB-connected Xbox controller can also be used to control a PTZ camera with Studio Monitor. To do this you must enable it for use in the settings area under **PTZ Controls**. You can also use an NDI®-enabled joystick controller like the PTZOptics SuperJoy for camera operation.

A little known feature in Studio Monitor is the built-in hot keys for PTZ camera operation. You can use the following hot keys as a camera operator to improve your workflow.

NDI Studio Monitor Hotkeys

Arrow keys : Pan, Tilt the camera.*

+/- : Zoom in, out.*

Page Up, Page Down : Focus in, out.*

Home/End : Exposure up, down.*

F : Toggle auto-focus on or off

E : Toggle auto-exposure on or off

1-9 : Recall preset.

Ctrl + 1-9 : Store preset.



*Hold CTRL key for higher precision control.

The most popular keyboard shortcuts for Studio Monitor.

- Arrow keys: Pan, Tilt the camera. Hold CTRL key for higher precision control.
- +/- : Zoom in, out. Hold CTRL key for higher precision control.
- Page Up, Page Down: Focus in, out. Hold CTRL key for higher precision control.
- Home/End: Exposure up, down. Hold CTRL key for higher precision control.
- F: Toggle auto-focus on or off.
- E: Toggle auto-exposure on or off.
- 1-9: Recall preset.
- Ctrl + 1-9: Store preset.

If you would like to access more advanced camera settings, click the cog in the right-hand side of your screen to access the NDI® camera’s management page. You can record video in Studio Monitor remotely by clicking the red “record” button in the web controller. This feature allows remote camera operators to record high-quality videos directly to their local hard-drive. These recordings can then be used in

post-production or for video analysis. For example, a sports coach could easily set up a picture in picture using two cameras. One camera captures up-close details, and a wide angle camera captures the entire field. These recordings can then be used for presentations with coaches and athletes. Coaches can even use an NDI® telestrator with a touchscreen to highlight plays just like you see in professional sports.

Needless to say, Studio Monitor is an important NDI® tool. While the design is minimalistic, the application is far from simple. Studio Monitor is a tool that is meant to provide users with a flexible and efficient NDI® viewing experience. Whether you are using a Mac or a PC computer, Studio Monitor will likely become a go-to application for your NDI® projects.

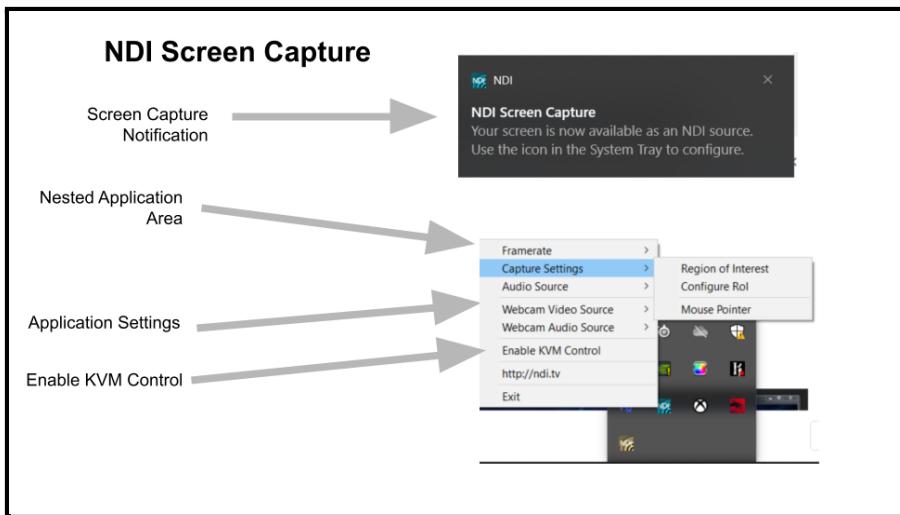
Key Takeaways:

1. Studio Monitor is a free software application available with the NDI® tools.
2. Studio Monitor is available for Mac or PC computers.
3. Studio Monitor can be remotely controlled via a network connected computer or device.
4. Studio Monitor offers a variety of advanced features available in the menu and web browser interface.

Chapter 15

NDI® SCREEN CAPTURE

Whether you need to capture a PowerPoint presentation, a software demonstration, or even high frame rate video gaming content, NDI® Screen Capture offers a solution. Using the NDI® Screen Capture application you can send video over the network, and access the video from any computer on your network. NDI® Screen Capture also supports connected webcams without the need for a capture device. This allows you to send a dual NDI® video stream with a screen capture and webcam together in one discoverable group of NDI® sources. Video captured by NDI® Screen Capture can be used by hardware or software video systems for streaming or recording. The NDI® video from Screen NDI® Capture is often used by a video switching software such as OBS or vMix to mix into a larger production as described in Chapter 5.

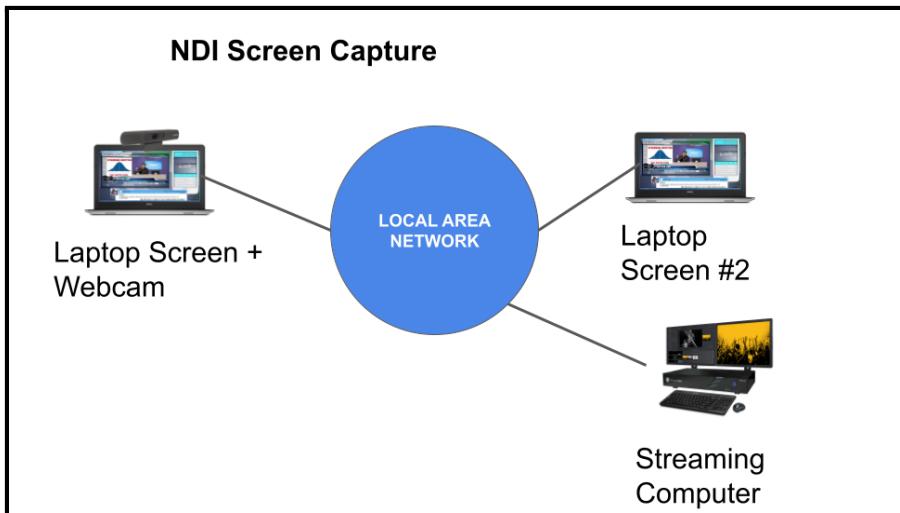


The NDI® Screen Capture app is generally nested in a system tray. This application runs in the background.

Getting Started with Screen Capture

It doesn't take much time to get started sharing screens with NDI®. First, go to ndi.tv/tools and download the tools for your computer (Mac or PC). Be sure that your computer is connected to the same network as the rest of your NDI® devices. Once you start the software, you will see a notice pop up on the screen saying "**Your Screen is Now Available as an NDI Source**". If you want to finetune the applications settings, access the settings area from your system tray. Right-click on the NDI® icon in order to choose a framerate, designate the area of the screen you wish to capture, and toggle on or off the mouse pointer from being captured. You can also select an audio source to capture. Keep in mind that you can send video from one or two monitors plus video from a connected webcam. You can also enable **KVM Control** which gives your keyboard and mouse control of the computer you are connected to. You can get keyboard and mouse control by connecting to the NDI® Screen Capture from the Studio Monitor application on another computer. This is a great feature because you already have live video, so it's easy to simply take control of a computer on your network running NDI® Screen Capture.

Pro Tip: If you are having issues discovering an NDI® source on your network, check each computer's IP address to ensure each is on the same IP range.



Two computers running NDI® Screen Capture. One laptop also includes a webcam and each is discoverable to the Streaming Computer.

Broadcasting, Streaming, Recording, and Viewing Screen Capture

Once NDI® Screen Capture is running, you can access it on the network like any other NDI® source. It can also be viewed on any instance of Studio Monitor, where you can use the local keyboard and mouse to control the computer running NDI® Screen Capture with the KVM Control feature enabled.

The More Efficient NDI | HX® Version

NDI® Screen Capture HX was released in 2021 and it provides screen capture capabilities with the high efficiency version of NDI®. The NDI | HX® protocol uses less bandwidth than NDI® HB, making it ideal in limited bandwidth connections. NDI® Screen Capture HX also takes advantage of NVIDIA's hardware for the highest possible quality with the lowest impact on CPU performance. NDI® Screen Capture HX is ideal for a variety of applications including capturing video gaming where framerate and computer performance are critical. NDI | HX® is also beneficial in cases where you want to capture a large

number of screens and need to carefully manage the bandwidth capabilities of your network.

NDI® Screen Capture & NDI® Screen Capture HX

The NDI® Screen Capture applications allow users to capture the screen of almost any computer without a video capture card. This includes full-screen displays, select screen regions, and any combination of windows and applications.

NDI® Screen Capture HX offers full resolution screen capture up to 4K at frame rates up to 120 Hz. It works seamlessly with NVIDIA GPUs on PCs to stream content via the NDI® network. NDI® Screen Capture HX uses end-to-end hardware acceleration to create high-quality video with very little latency. The main drawback to the NDI® Screen Capture HX currently is that it does not support additional video via a webcam source.

Both NDI® Screen Capture and NDI® Screen Capture HX work well with popular video production and switching solutions such as TriCaster, OBS, vMix, and Wirecast. For PCs equipped with an NVIDIA GPU, look into updating the graphics cards to support the new NVENC encoder. NDI® is using the latest technology from NVIDIA to further improve the performance of NDI® video streaming.

Key Takeaways:

1. NDI® Screen Capture is a free application available in the NDI® tools.
2. NDI® Screen Capture is used to connect almost any computer screen to the network.
3. A new NDI® Screen Capture HX software is available to provide the highly efficient NDI|HX® format for screen

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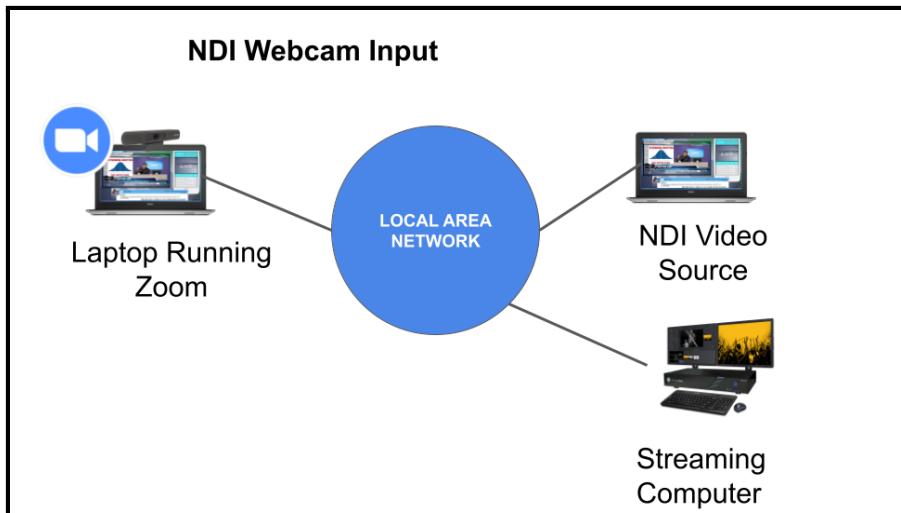
capture.

Chapter 16

NDI® WEBCAM INPUT

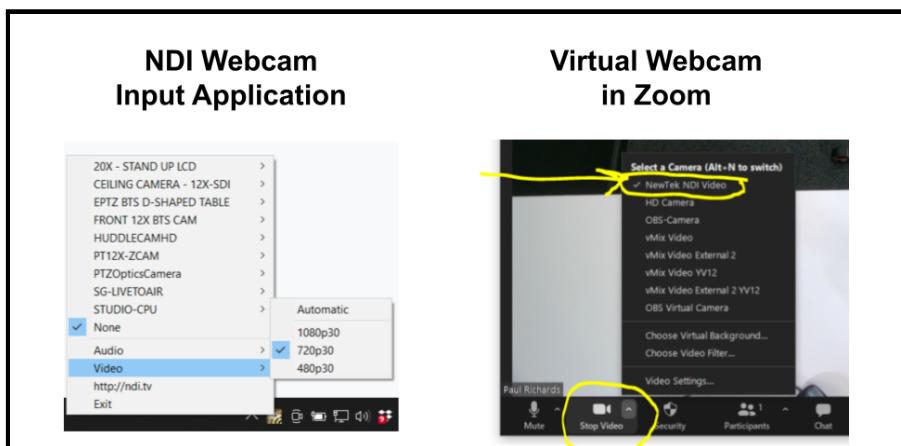
The NDI® Webcam Input is a welcome addition to the NDI® tool kit. The tool is designed to improve the use of NDI® with popular video communication software such as Google Hangouts, GoToMeeting, and Zoom. NDI® Webcam Input allows you to access NDI® sources with a virtual webcam that is selectable inside of any application that works with webcams. Because most video communication solutions are designed to use a webcam as the video source, NDI® has created a virtual webcam driver that shows up just like a regular webcam. The application, which lives in your system tray, allows you to select between any NDI® source on your network and display it as a webcam.

NDI® Webcam Input makes it possible to use any NDI® source in place of a regular webcam. As an example, imagine that you are conducting a Zoom meeting and you want to show the meeting participants an NDI® video source on your network. You could choose an NDI® source from a video production studio that has access to multiple cameras, or you can choose an NDI® source like a PTZ camera to show a specific area of your office. It's handy to switch between NDI® sources using a NDI® Webcam Input without having to connect each video source to your computer with USB like regular webcams.



A laptop running Zoom where a NDI® Webcam Input serves as the webcam inside of Zoom. This allows you to select from various NDI® sources on the network to show the inside of Zoom just like a webcam.)

To use NDI® Webcam Input, download the latest version of NDI® tools at ndi.tv/tools. Once installed, launch the software and find the program icon in the system tray. During installation, you will be given the option to run NDI® Webcam Input at start-up. This is useful if you plan to use NDI® Webcam Input as the default video source for your video conferencing software.



Side by side comparison of the NDI® Webcam Input application and the virtual webcam driver which is available in platforms like Zoom.

Right-click the software icon to access a list of all available NDI® sources. When you click on an NDI® source, it's ready to be used as a webcam source under the name "**NewTek NDI Video.**" From within your video conferencing software, choose **NewTek NDI Video** as your webcam source, which will show the NDI® source you have selected. You may also select an NDI® source for your audio using a virtual audio option called "**NewTek NDI Audio.**"

Because you can choose any NDI® source, you're also able to share the program output of another video switcher, a single camera, screen capture, or any other NDI® source. You can even designate an iPhone connected to the NDI® network via WiFi as your NDI® source. This is particularly helpful for switching between multiple cameras and video assets with a production software like OBS. This also allows you to bring professional cameras and graphics directly into video communication tools.

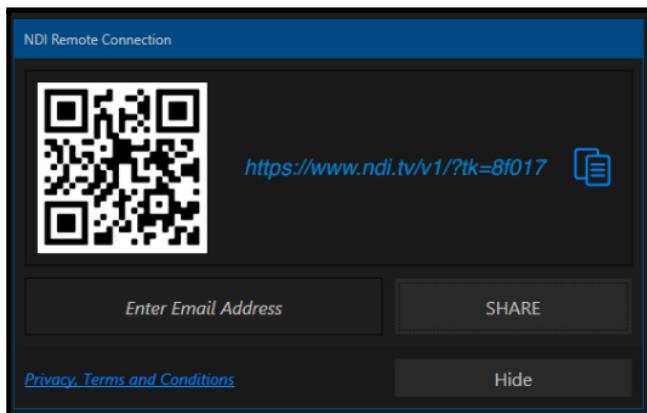
Key Takeaways:

1. NDI® Webcam Input is a free tool available in the NDI® tools.
2. NDI® Webcam Input can be used to make any NDI® source on the network available as a webcam inside any application that uses a webcam (Skype, Zoom).
3. NDI® Webcam Input is an application that lives in the system tray.

Chapter 17

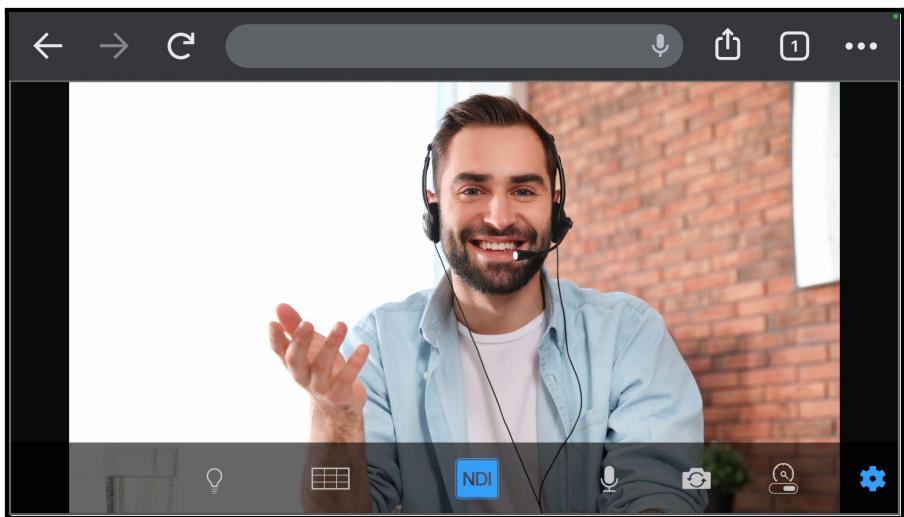
NDI® REMOTE

NDI® Remote is a tool to share or receive an NDI® source over the internet. The tool allows you to quickly send a link to someone you would like to send video into your production. NDI® Remote is managed directly through NDI® Studio Monitor and it allows you to create a remote connection with another computer using a link. NDI® Remote is designed to support one remote NDI® source. In the next chapter, you will learn about NDI® Bridge which is designed to send groups of NDI® sources over the internet.



NDI® Remote Connection has the ability to create a link or scan a QR code.

NDI® Remote offers the option to create a link and share it with someone via email. It will also create a QR code which can easily be scanned by a smartphone. The system uses WebRTC, an industry-standard technology used for sharing audio and video sources over the internet. The great thing about WebRTC is that it will work with almost any computer that has a modern web browser. Google Chrome is a popular web browser that works with WebRTC.



NDI® Remote used with a web browser.

Once the far end device has connected to the link provided by NDI® Remote video will be made available on the local area network (LAN) as an NDI® source. In the picture above you can see, there are multiple options available to adjust the video being sent over the internet. For example, small icons are available to control lighting, mute audio and choose resolution options. Users can decide to mute their microphones, switch cameras, adjust video settings and more. NDI® Remote is an easy tool to bring remote guests directly into an NDI® video production environment.

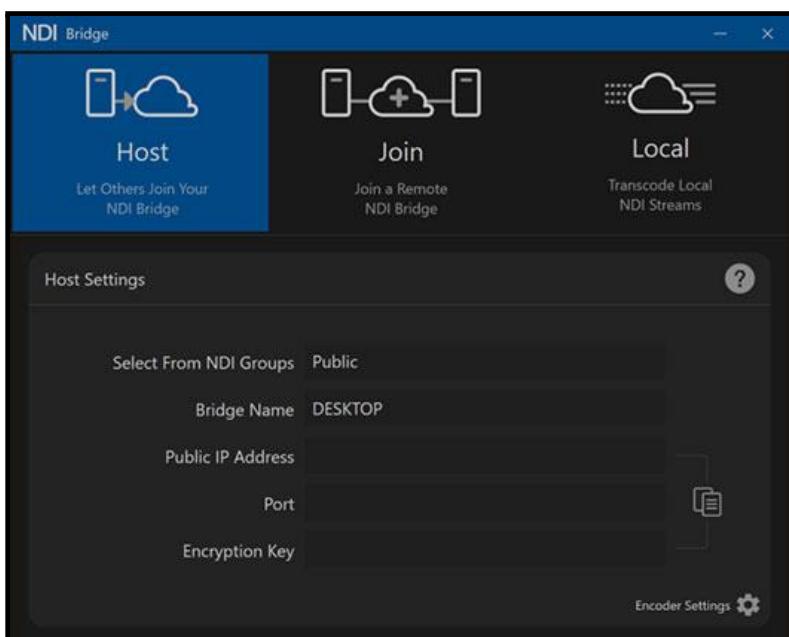
Key Takeaways:

1. NDI® Remote is a simple way to connect a remote video source to your NDI® production environment.
2. NDI® Remote uses WebRTC which provides a single link to link a remote site into a NDI® video production environment.

Chapter 18

NDI® BRIDGE

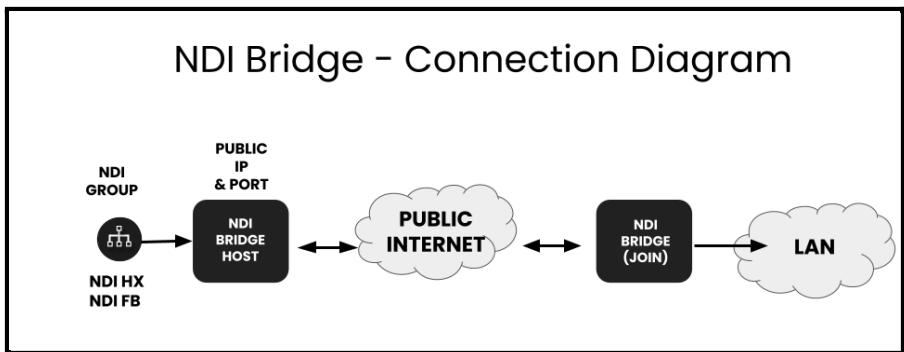
NDI® Bridge is a tool designed for sharing NDI® video sources beyond a local area network (LAN) using the Wide Area Network (WAN), also known as the “Public Internet.” NDI® Bridge was released in 2021 with the NDI® 5.0 toolset, along with NDI® Remote and Audio Direct tools. Until NDI® Bridge was released, many video productions used NDI® only for LAN video traffic and relied on technologies such as Secure Reliable Transport (SRT) or video communication solutions like Zoom to transport video over the public internet. NDI® 5.0 supports a technology called Reliable User Datagram Protocol (RUDP) which is a point-to-point video transport protocol that allows for high quality video transport over public networks.



NDI® Bridge application open to the “Host” tab.

The NDI® Bridge has three main components that allow users to advertise and transport NDI® video over the WAN. First, users can set up their Host connection. The Host connection allows others to join the NDI® Bridge that is set-up on one side of the connection. Here, you can select a group of NDI® sources to be transported over the WAN to a receiving location anywhere in the world. You will learn more about setting up groups of NDI® sources with Access Manager in the next chapter. Using NDI® Groups, the NDI® Bridge can send an entire group of NDI® HB or NDI HX® video sources together over the public internet.

NDI® Bridge does require a public IP address and an open port to operate properly. You can request a public IP address through your Internet Service Provider (ISP). Ports for video traffic can be created through the router connected to the WAN. Once the public IP address and open port are set up, a host connection can be accessed through the public internet.



NDI® Bridge connection diagram uses the public internet.

From the far end of an NDI® Bridge connection, the same outside IP address and port number information is necessary to send video. Once both ends of the NDI® Bridge are connected, the NDI® sources available on the host side will be made available for the far end side to use just like local NDI® sources.

NDI® Bridge supports NDI® video source capabilities including alpha channel, PTZ controls, KVM, Tally, and Metadata. Alpha channel support is necessary for many broadcast graphics applications. Graphics overlays are a use case for NDI® Bridge used with alpha channel video. Alpha channel video supports a transparent background that overlays on top of another video source. In this way, NDI® Bridge allows remote productions to bring alpha channel graphics into a production environment from anywhere in the world.

PTZ camera controls open up another interesting use case in which NDI® Bridge is used to send video from a PTZ camera where the PTZ cameras can be controlled from a remote location. KVM, a popular abbreviation for “Keyboard, Video, and Mouse” can be used to pass along remote controls for computer screens captured with KVM support.

NDI® Bridge will also maintain support for Tally, the technology that alerts camera operators and on-screen talent when a camera is in use. This is an interesting feature which would allow a remote production to know when a specific NDI® video source is being used even from a remote production. The Tally feature of NDI® will be discussed in more detail in Chapter 19. Finally, some metadata is also transported over the NDI® Bridge which includes information such as NDI® source-friendly names. Metadata makes NDI® video more usable by providing information that compatible NDI® systems can use to display relevant information to producers working with the video.

While NDI® Bridge does have some technical requirements before it can work, it provides powerful connectivity options. In comparison to established wide area network (WAN) video transport solutions like Secure Reliable Transport (SRT), NDI® simplifies set-up by requiring a single port to support multiple video channels. NDI® Bridge provides the opportunity for many productions to think outside of their own local area networks (LAN) to implement video projects that incorporate video from around the world.

Key Takeaways:

1. NDI® Bridge allows you to connect with NDI® sources over

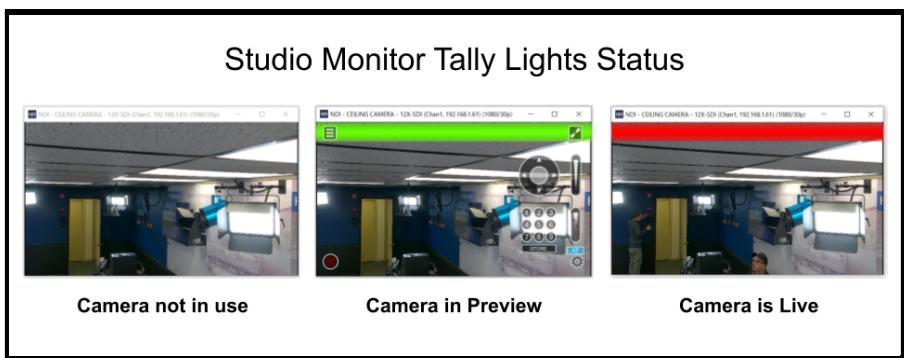
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- the public internet.
2. NDI® Bridge can send groups of NDI® video sources e using the latest video transport methods available today.

Chapter 19

NDI® TALLY

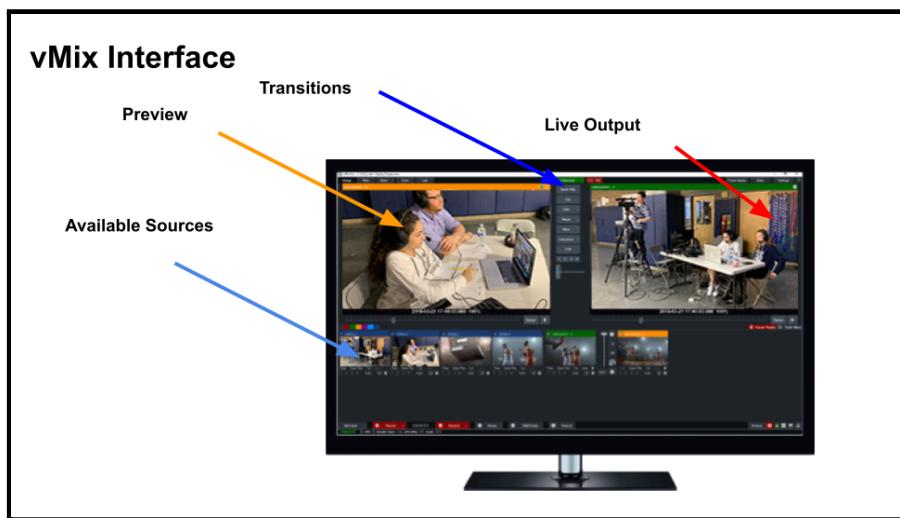
NDI® and its creators have roots in the broadcast industry which is why NDI® supports many broadcast technologies. One such technology is tally. A tally light is an indication light which informs you about a specific camera's status in a production. For example, each camera can have a tally light associated with it. The tally light will turn red when the camera is live on-air. When a light turns red, the onscreen talent knows which camera to look at. NDI® supports tally indications with mobile phones, screen capture sources, and much more.



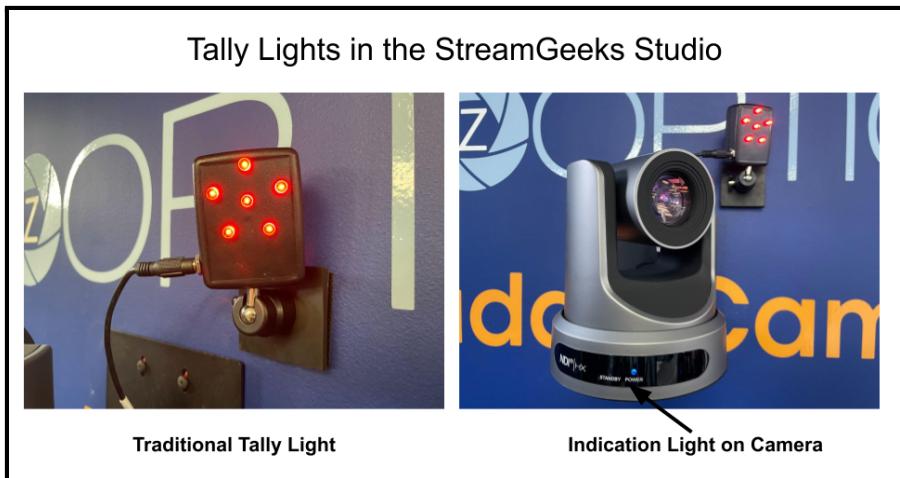
From left, the first image is an NDI® camera that is not being used in a video production. The middle image shows a green bar indicating that the camera is in preview, and the third image shows a red bar indicating that the camera is live.

A great way to see the built-in tally light functionality of NDI® is to use the Studio Monitor application. If you place that source in the preview or output position of a video production software like OBS, Wirecast, or vMix, you will notice a green or red outline around the source in Studio Monitor. This outline communicates how that source

is currently being used in a production.



Standard video production software with preview and live output area. NDI® devices use the tally light function in different ways. PTZOptics cameras, for example, have built-in tally light support that uses an indication light on the front of the camera. Because PTZOptics cameras have NDI® built-in, the cameras turn on a light when the camera is in output mode, and blink when the camera is in preview mode. The tally light will turn off entirely when the camera is neither preview or output mode.



Two different types of tally lights.

Other NDI® devices that support tally lights include NDI® encoders and decoders. The NewTek Spark, for example, offers indication lights for camera operators. NDI® encoder devices connect to broadcast cameras which makes the tally light helpful for camera operators so they can know when the camera is being used for a production. A tally light on an NDI® encoder may be hundreds of feet from the production computer but because it is connected over the network, the tally light signal can be maintained with minimal latency.

Finally, there are complete tally light solutions that have been designed for NDI®. Tally-Lights, LLC makes an NDI® controller designed to support up to eight tally lights. The NDI® tally light controller can be connected directly to a network and configured via a web browser. The controller can then be set up to turn on up to eight lights individually as each NDI® source in the studio is being used. Tally lights are often overlooked during the design process of new video recording and streaming applications. Luckily, NDI® supports tally lights through a variety of options which help users better communicate with on-camera talent and members of the production team.

Key Takeaways:

1. Tally lights are a tool to keep on-screen talent and camera operators informed about a production.
2. NDI® supports tally light functionality; it is a built-in option for NDI® tools such as Studio Monitor.
3. Tally lights can be set up with NDI® and non-NDI® cameras.

Chapter 20

NDI® AUDIO DIRECT

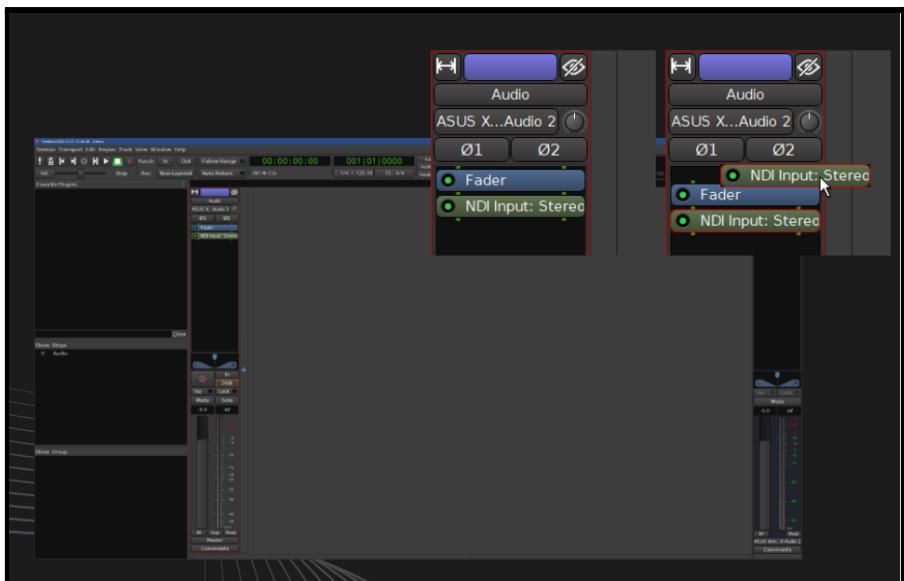
NDI® Audio Direct is a tool for managing and enhancing NDI® audio sources on the local area network (LAN). NDI® Audio Direct allows you to use any Digital Audio Workstation (DAW) software that supports Virtual Studio Technology (VST) plugins. DAW software solutions are used by audio engineers and musicians to manage multiple audio sources. Popular DAW software includes Ableton, Ardour, Audacity, Cubase, GarageBand, Logic Pro, and Pro Tools among others. VST plugins are a popular way to enhance the DAW's capabilities by adding additional functionality. NDI® Audio Direct can interface with any DAW that supports VST 3 or LV2 plugins.



Audio plugins are available with NDI® Audio Direct.

Once installed, NDI® Audio Direct creates two audio plugins that are available for use with compatible DAW software. One plugin is designed for bringing NDI® audio sources into DAW software, and the other is designed for outputting NDI® audio. The ability to input and output audio directly into any DAW allows users to manage NDI® audio sources with the industry's most professional audio management tools. One way to use NDI® Audio Direct is to incorporate multiple NDI® audio sources into a larger audio production. Another example involves using DAW software to enhance NDI® audio inputs with a

compressor, a noise suppressor, or any of the thousands of advanced audio processing tools available today.



The NDI® Audio Direct plugin is used with the Ardour DAW.

NDI® Audio Direct opens NDI® up to the professional audio production world. Similar to NDI® Webcam Input which opened up the world of webcam-enabled software, NDI® Audio Direct opens up the world of VST 3 enabled software.

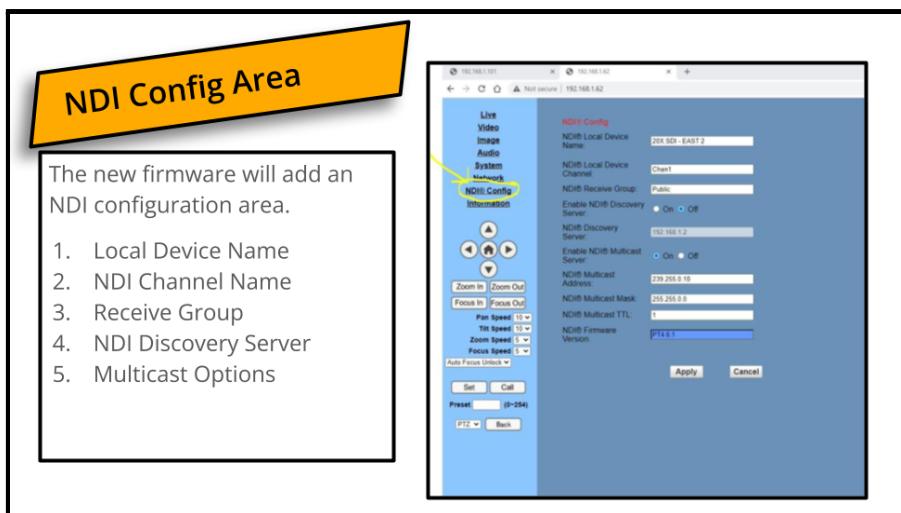
Key Takeaways:

1. Digital Audio Workstation (DAW) software records, edits, and produces professional audio.
2. NDI® Audio Sources can be integrated into any DAW that supports VST 3 or LS2 plugins.

Chapter 21

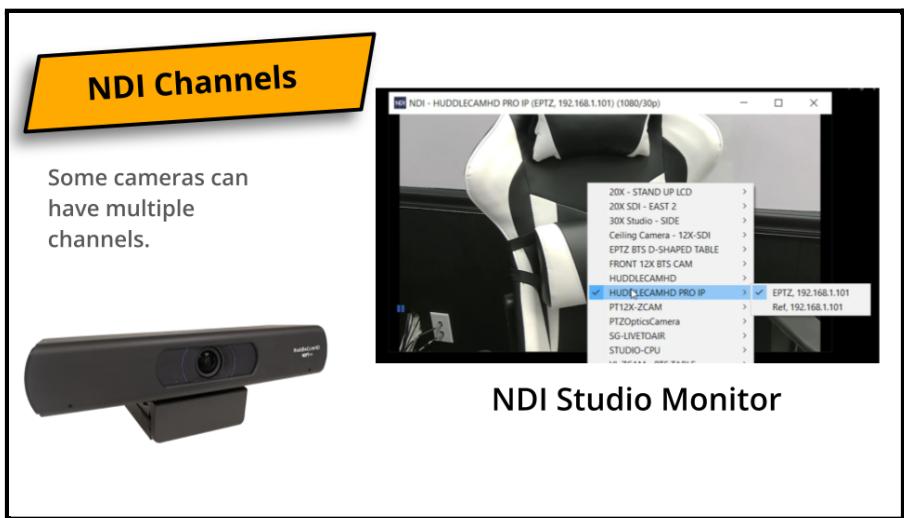
NDI® UPDATE NOTES

The release of NDI® version 5.0 offers improvements in video quality, security, and NDI|HX® compression formats. NDI® cameras like PTZOptics can have their firmware upgraded to support NDIv4, which is becoming the standard for NDI|HX®-enabled hardware products. This update includes improvements to NDI|HX® for lower latency and GPU decoding acceleration. Apart from video improvements, NDI® Groups can now be used with Access Manager to increase security. This includes custom device naming to increase usability. New multicast features now make NDI® easier to use and more flexible than ever. Simply put, NDI® is frequently updated and maintained to provide a high level of functionality.



Web interface for an NDI®-enabled PTZOptics camera open to the NDI® Config tab.

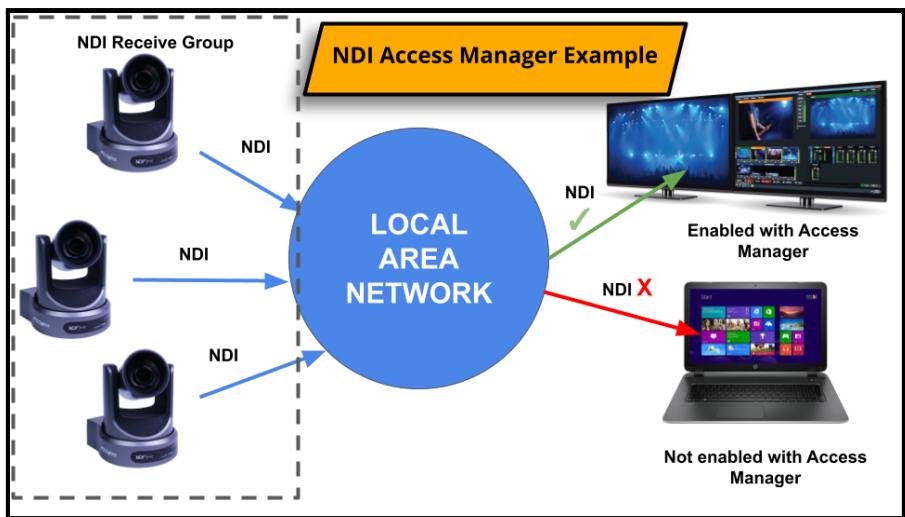
The NDI® Config tab in PTZOptics cameras helps to illustrate some of the new features. The tab demonstrates how you can set up a local device name and channel. The **Device Name** is a label that will show up in other NDI®-compatible hardware and software. The **Channel Name** is particularly important for cameras that support multiple NDI® channels, like the HuddleCamHD Pro IP. This NDI® webcam supports two channels of NDI® video. When a camera has multiple NDI® outputs, you can name and manage them from a drop-down list. For example, the HuddleCamHD Pro IP features one NDI® output for the wide angle view and one for use with an electronic pan, tilt, and zoom view that is adjustable.



HuddleCamHD Pro IP with two unique NDI® channels. The device shows up once in Studio Monitor but includes two selectable channels.

You may also notice a new **NDI® Receive Group** which is available to enhance security for your NDI® sources on the network. Once you start using a lot of NDI® sources on your network, you may want to consider who has access to those sources. This is especially true for NDI® sources which include PTZ camera controls. Using NDI® Access Manager, you can set up custom receive groups so that only

specific computers on your network can actually discover the NDI® video sources on your network.



Example showing how NDI® Access Manager can enable some computers to discover NDI® sources and restrict others.

The example above shows how you can set up NDI® devices on a secure receive group name. This receive group name can then be used with NDI® Access Manager on a computer you would like to receive access to the sources. No other computers on the network will be able to see the NDI® sources unless you set up the NDI® Access Manager with the custom receive group. This is a great way to protect your NDI® sources from unwanted viewers or camera operators on your network.

NDI® also now supports a freely available NDI® Discovery Server which increases what you can do with NDI® on complex networks. It's also ideal for mini networks that do not have a router. The Discovery Server allows you to manage each NDI® device on your network to make NDI® source discovery work smoother in a variety of networking environments.

A new auto-generation tool for multicast addressing is also now available. Multicast is a technology that will be covered later on in this book. The feature allows networks to send and receive multiple video feeds at the same time without congesting a network with on-demand video traffic.

NDI® has constantly pushed the boundaries of video production over IP. NDI® 5.0 has been no exception. Building on the already revolutionary ability to record unlimited NDI® video channels for true multi-camera editing with full synchronization, NDI® 5.0 offers the unprecedented integration and power to move video and audio between devices anywhere around the world using new tools designed to bridge LAN based NDI® with video from the WAN (Wide Area Network).

Here are some of the new features built into NDI® 5.0:

- NDI® Bridge - An app designed to transfer video over long distances without any 3rd party applications.
- NDI® Remote - This app can be used to connect with individuals and receive their audio and video using just a link to turn any Internet-connected device into an audio/video source.
- NDI® Audio Direct - A new tool designed for the integration of audio into NDI® workflows.
- An update for reliable UDP support makes WAN and WiFi connections more resilient with less configuration.
- An update to support MacOS and ARM-based CPUs.

Key Takeaways:

1. New versions of NDI® come out on a regular basis.
2. Recent NDI® releases have included the optimization of NDI® as a whole and new tools.

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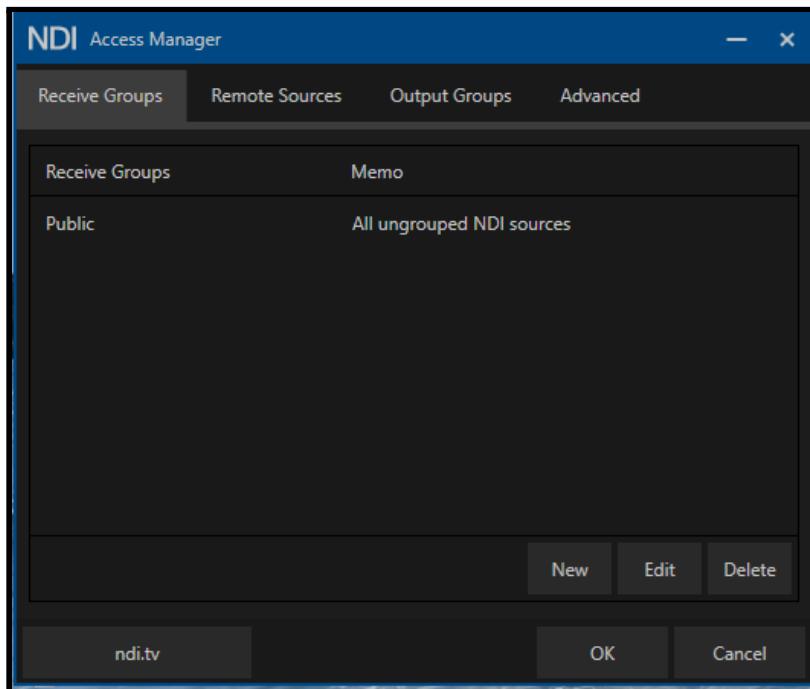
3. Some new NDI® tools are now available for use to remotely contribute to and control NDI® video productions.

Chapter 22

NDI® ACCESS MANAGER & DISCOVERY SERVER

GUEST CHAPTER BY MATTHEW DAVIS

NDI® Access Manager is a free application included with NDI® Tools that allows you to manage NDI® sources on your network. NDI® Access Manager can be used to organize and manage groups of video sources for ease of use and security. NDI® Access Manager increases the security of your IP video sources by restricting access to specific computers on your network. Organizing the NDI® sources on your network into groups becomes important when you plan to send video sources over the public internet using NDI® Bridge which allows you to select entire groups of NDI® sources to work with. When NDI® sources are grouped together, they appear in NDI®-compatible software nested into an organized group. This may be ideal if you have multiple studios or spaces with NDI® sources on your network.



NDI® Access Manager is open to Receive Groups.

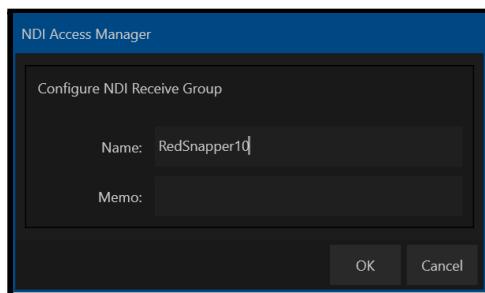
Receive Groups:

By default all NDI® sources are set to a “Public” group. Receive Groups allows you to "hide" NDI® resources on the network that are only discoverable on your network by a computer with access to the group credentials via Access Manager. To use the NDI® Receive Groups, you must first define a Group name on the NDI® source. NDI® Access Manager is then used to define who has access to sources in each group.

If you are using a PTZOptics camera this can be found in the **NDI® Config** section of the camera’s web interface. Each NDI® device will have this information in a slightly different location. The default Group will be set to "public" which allows the source to be seen by any NDI®

receiver on the same network. If you delete "public" and replace it with something unique such as "RedSnapper10," the NDI® source will only be discovered by receivers also joined to the "RedSnapper10" Receive Group with Access Manager. Receivers can be joined to multiple NDI® Groups by simply using ",". For example, "RedSnapper10,RightStage" would be joined to both RedSnapper10 and RightStage NDI® Groups.

Once you have set up your NDI® Group assignment on your NDI® Source, you now need to use Access Manager to "join" those NDI® Groups. On the NDI® Receive Groups tab click "New" and it will allow you to join specific NDI® Groups by simply entering the same NDI® Group Name used on the NDI® Sources.



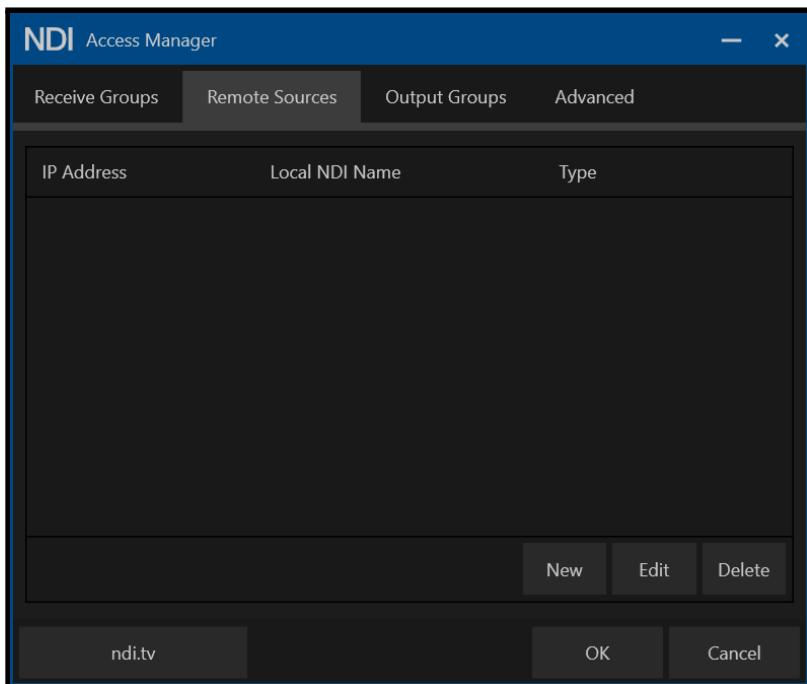
NDI® Access Manager is used to set up an NDI® Receive Group.

If you click "**OK**" your NDI® Software will now be able to see the NDI® Sources joined to RedSnapper10 even though other PCs are not able to access them.

The Remote Sources feature allows you to create static entries for devices across your network, or even those accessible via public IPs or Dynamic DNS. Remote Sources is also an easy way to name and group

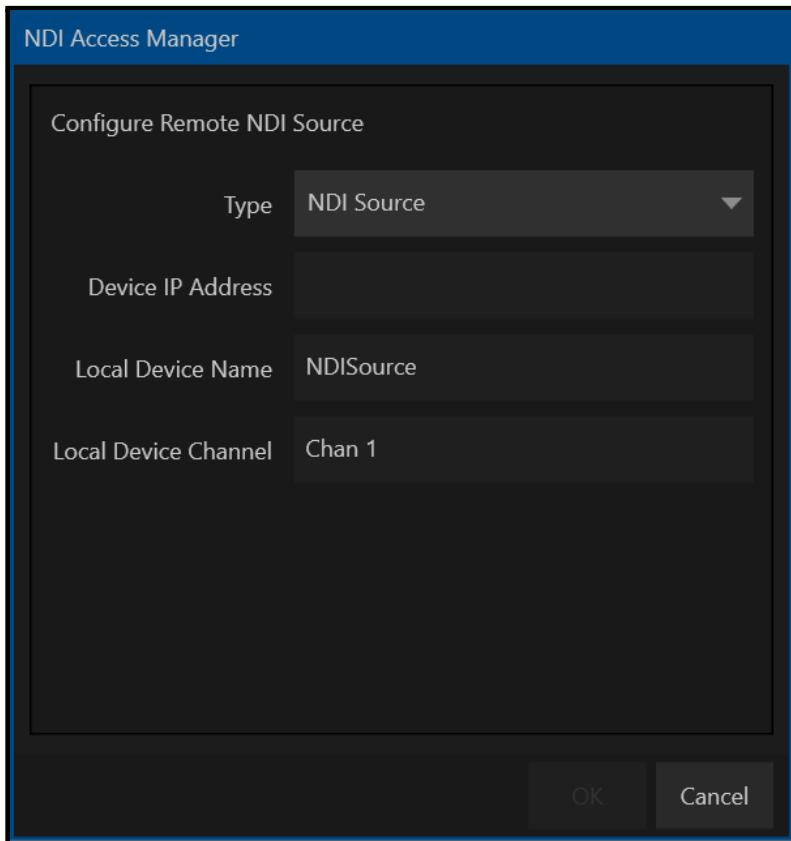
your sources.

Please Note: If you are experiencing simple discovery issues, defining the NDI® source in the Remote Sources section should solve basic discovery issues. Note that discovery issues can be indicative of other network issues that could prevent reliable use of NDI®.



NDI® Access Manager is open to “Remote Sources”.

To add a new "Remote Source," click on the "New" button at the bottom of the "Remote Sources" tab. A new window will open to create your remote source entry.

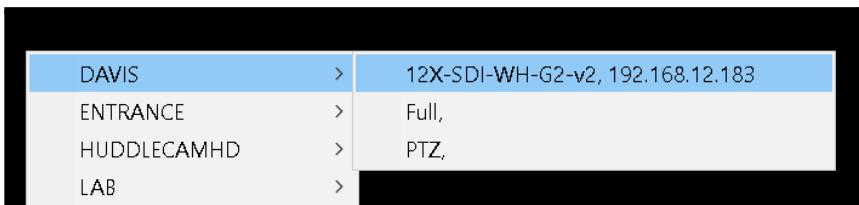


NDI® Access Manager is used to configure a Remote Source. Here are the steps to add a new “Remote Source”:

- **Type:** Using the Type drop-down menu, select the appropriate option for the device you are trying to configure. If you are using a PTZOptics camera with the original implementation of NDI|HX®, select the "PTZOptics Camera" option. If you are running the latest PTZOptics firmware featuring NDIv4|HX, you should select the "NDI Source" option.
- **Device IP Address:** This is where you will enter the static

IP address (locally or as a public IP) of the NDI® source. You can also use Dynamic DNS entries in this text box.

- **Local Device Name:** This is a field that allows you to organize and potentially group multiple NDI® sources under a single category. As you add more sources you can use the same Local Device Name so that they all show up together under the same NDI® header. For example, see the picture below with multiple "sources" available under the "DAVIS" Local Device Name.



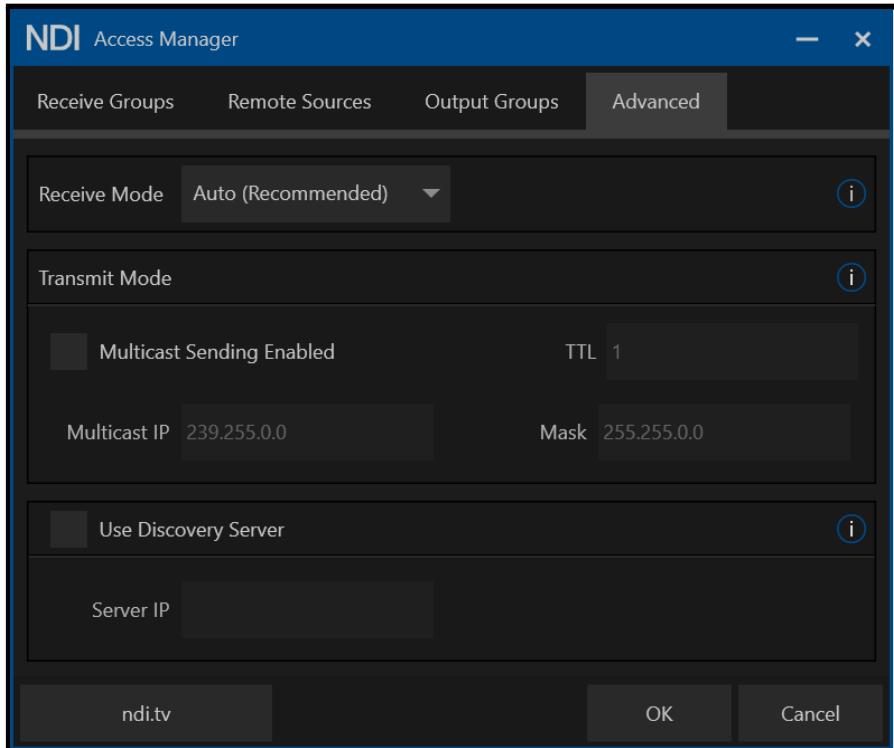
NDI® Studio Monitor with video source nesting capabilities.

- **Local Device Channel:** This is where you can identify the unique NDI® source with a title such as "Stage Left" or "Overhead View" to help organize your NDI® sources.

Click on the "OK" button to complete your configuration.

- **Output Groups:** This feature functions in a similar way as the NDI® Receive Groups discussed above. The main difference is that your PC is capable of sharing its NDI® outputs with NDI® Groups.
- **Advanced:** Use this section if you need to "tune" your NDI® network feeds to meet specific network requirements

such as using multicast, forcing TCP / UDP to use the NDI® Discovery Server.



NDI® Access Manager]in Advanced mode.

- **Receive Mode** allows you to dictate the communication method for receiving content on your PC and allows you to select between the following options depending on your network configuration and architecture:
 - Auto (Recommended)
 - User Datagram Protocol (UDP) (*Legacy*)
 - Multi-Transmission Control Protocol (TCP) (*Legacy*)

- Single-TCP
- Reliable UDP
- **Transmit Mode** enables multicast sending from your PC over your LAN. You should not enable multicast on your PC or other NDI® sources unless you can confirm the network has been configured to support the use of multicast traffic.
- **Discovery Server** allows you to run a free application that acts as the central point for NDI® discovery across a network.

NDI® Discovery Server

Using the NDI® Discovery Server may help mitigate certain issues related to mDNS traffic on computer networks. This guide will demonstrate how to install and start the NDI® Discovery Server and show you how to connect your cameras and computer to the server.

1. The NDI® Discovery Server is located in the NDI® SDK. Download the NDI® SDK here:
<https://www.ndi.tv/sdk/>
2. The NDI® Discovery Server is a lightweight application that can run on your computer. You will need to know the IP address of the computer on which it is running. We recommend setting a static IP address on this computer.
3. Once you have downloaded the NDI® SDK, you will need to navigate to the Discovery Server folder:

C:\Program Files\NewTek\NDI 4

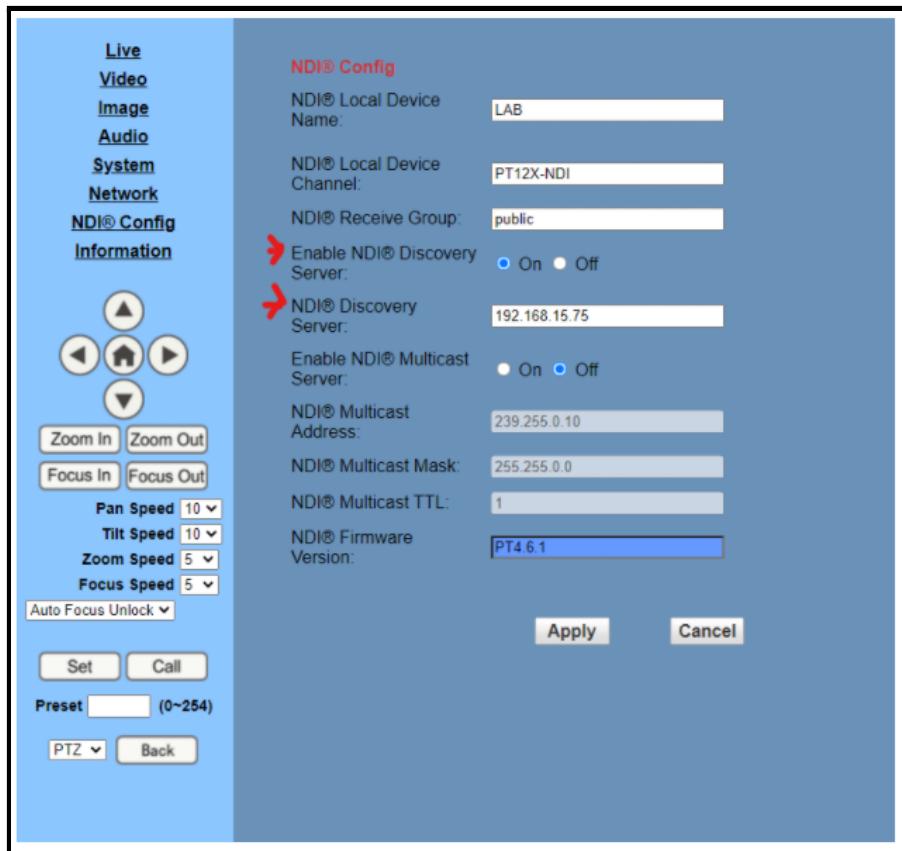
SDK\Bin\Utilities\x64\

4. The file is “NewTek NDI Discovery Service.exe”. Double click on the application to start the NDI® Discovery Server. You will see a window like the one below:



NDI® Discovery Server..

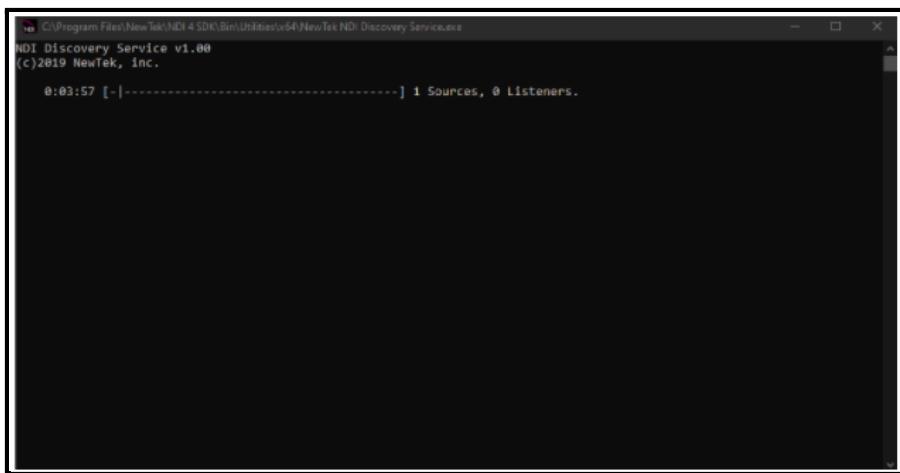
5. There are zero NDI® Sources and zero NDI® Listeners.
6. Navigate to the NDI® Config section of a NDIv4 camera. You will enable the Discovery Server and then enter the server's IP address.



NDI® device with NDI® Discovery Server capabilities.

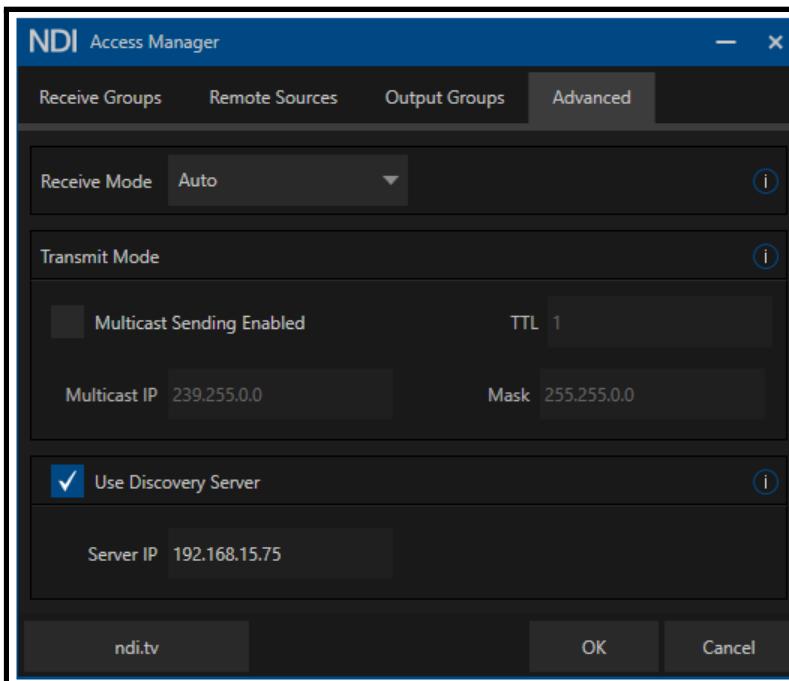
- After applying this information and rebooting the camera, you should see “1 Source” listed in the NDI® Discovery Server. This is your camera:

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NDI® Discovery Server shows an available source.

8. Point your computer to the NDI® Discovery Server, open the NDI® Access Manager, and click on the Advanced tab.



9. Select “Use Discovery Server” and enter the IP address of your discovery server. Click “OK”.
10. Open NDI® Studio Monitor and a “new listener” will appear in your NDI® Discovery Server.



NDI® is now using your computer for discovery instead of mDNS. Follow this process for all NDI® sources and listeners on your network.

Access updates to these instructions in articles written by Matthew Davis at: help.ptzoptics.com.

Key Takeaways:

1. NDI® Access Manager is a tool used to group NDI® sources.
2. NDI® Access Manager allows you to increase the security of

your IP video system.

3. Use NDI® Access Manager c to organize r a specific group of NDI® sources that are transported over the public internet using NDI® Bridge.
4. NDI® Discovery Server can help you improve NDI® source discoverability in certain cases.

Chapter 23

MULTICAST

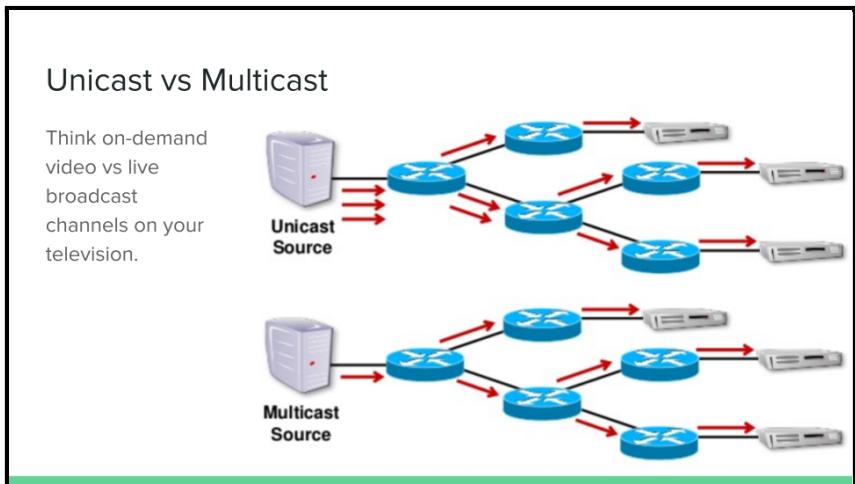
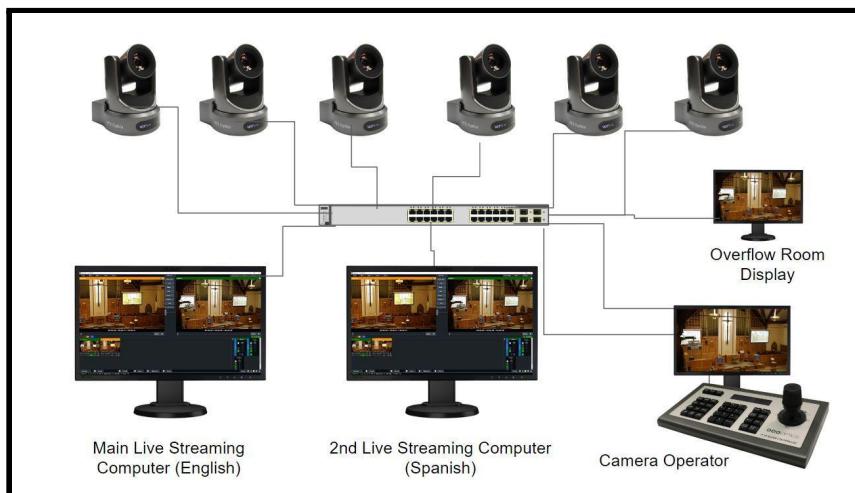


Diagram shows the difference between Unicast and Multicast.

Multicast is a method of sending data to multiple computers on your local area network (LAN) without requiring additional bandwidth for each receiver. Multicast is very different from Unicast which is a data transport method that opens up a unique stream of data between each sender and receiver. Multicast allows you to broadcast video from a single camera or computer to a channel of receivers inside your LAN. Using a multicast channel you can send video without accumulating additional bandwidth on your network for each receiving device.

Multicast technology exists inside television receivers. When you request an on-demand video from a cable television provider, this opens up a unicast stream for the unique video that you have requested. When you flip through the hundreds of available television channels, you are flipping through multicast channels. This is how your cable television provider can send thousands of video channels to your television using the same ethernet cabling used for your LAN. Multicast

is an effective way to distribute NDI® video on any network that is multicast-enabled.



Multicast video channels can produce two different versions of the same production. One production uses the camera feeds to produce a show in English. The second live streaming computer uses the camera feeds to produce a show in Spanish.

In the diagram above, you can see that there are six multicast enabled NDI® cameras. Because these cameras are enabled for multicast, the video feeds can be accessed simultaneously by multiple computers on the network. Therefore, a second computer dedicated to a Spanish-language production can use the video feeds at the same time as the main, live streaming computer. In this example, there is a translator providing Spanish audio available to the second live streaming computer. There is also a third computer using the NDI® video feeds simultaneously for camera operation. In this example, a camera operator pulls in the NDI® video feeds, along with an overflow display in another room.

MODEL	AREA	POE	IP ADDRESS	MULTICAST ADDRESS
PT20X-NDI-GY-G2	CHURCH FRONT	Y	<u>192.168.100.31</u>	234.1.0.31

PT20X-NDI-GY-G2	CHURCH FRONT	Y	<u>192.168.100.32</u>	234.1.0.32
PT20X-NDI-GY-G2	CHURCH FRONT	Y	<u>192.168.100.33</u>	234.1.0.33
PT20X-NDI-GY-G2	CHURCH FRONT	Y	<u>192.168.100.34</u>	234.1.0.34
PT20X-NDI-GY-G2	CHURCH SIDE	Y	<u>192.168.100.35</u>	234.1.0.36
PT20X-NDI-GY-G2	CHURCH FRONT	Y	<u>192.168.100.36</u>	234.1.0.36
PT-JOY-G2	BROADCAST AREA		<u>192.168.100.37</u>	N/A
TRICASTER TC1	BROADCAST AREA	N/A	<u>192.168.100.113</u>	234.1.0.113

When you use multicast video it's important to note that each device requires a unique multicast IP address. The IP address table above is an example that shows how to organize this data as your video productions grow. Multicast addresses can range from 224.0.0.0 to 239.255.255.255 on most networks. If you want to leverage the power of multicast video, you must remember to select networking equipment that can support multicast network traffic. This is especially important for wireless access points. Notice how each camera has a unique IP address and a unique multicast address. NDI® now offers a Multicast Discovery Server which can automate the process of setting up multicast devices on your network.

NDI® is so easy to use that it hides some of the complex networking technology required for operation. In many basic NDI® deployments, multicast may not be necessary. However, multicast is becoming easier to use and more commonly supported by networking systems. With a basic understanding of multicast, video production experts can accomplish tasks that were virtually impossible with IP video.

Key Takeaways:

1. Multicast is a technology that enhances the way NDI® is distributed.

THE UNOFFICIAL GUIDE TO NDI®

2. Multicast is a more efficient way to deliver IP video than Unicast when there are multiple receivers of the same video channel.
3. New updates to NDI® continue to make using Multicast easier.

Chapter 24

IT'S YOUR TURN

Whether you have a portable video rig with just a couple of cameras and a laptop, or you are building a professional broadcast studio with multiple cameras, video workstations, and a professional hardware switcher, NDI® makes set-up and operation more efficient and cost-effective.



From left: Tess Protesto, Dr. Andrew Cross, and Paul Richards.

As the need for video production technology continues to grow, so have modern consumer demands. Consumers, more sophisticated “prosumers,” and seasoned professionals alike are growing tired of using costly hardware converters and capture cards for traditional video production. The limitations presented by traditional HDMI and SDI video cabling have left too many people scratching their heads, wondering if there is a better way. NDI® represents a paradigm shift that makes the transition to an IP workflow easy. From high resolution,

frame rate, and low latency support, to the convenience of IP connectivity, NDI® checks all the boxes for most video professionals.

If you want to learn more about NDI®, find compatible hardware and software, and discover the latest developments and offerings, you should visit the NDI.tv website. You can learn more about NDI® and download all of the NDI® tools directly from this site.

Developers can also learn about and download the latest NDI® Software Development Kit (SDK) to incorporate NDI® into their own solutions. The site offers a marketplace with links to NDI®-compatible devices, cameras, graphics software, converters, and more. In addition, NDI.tv offers a community section with links to the latest news, tutorial videos, and NDI® forums. These forums are a great place to search for community help and advice on NDI® topics.

No matter your production environment, NDI® has the tools you need to harness the power of network connectivity to get the most out of your video productions. Feel free to contact me about NDI®.

Remember there is an online course with this book you can watch on YouTube or via Udemy here:

<https://www.udemy.com/course/newtek-ndi/>



Scan this code to get to the online course.

Sincerely,

Paul Richards
paul.richards@streamgeeks.us

ABOUT THE AUTHOR



Paul Richards is a father, author, and business executive leading his company in the field of video communications. Richards is the author of multiple top-selling books including, “The Virtual Ticket,” “The Online Meeting Survival Guide,” and "Helping Your Church Live Stream."

Richard’s books draw from his hands-on experience in the audio visual technology industry. As the Director of Business Development for HuddleCamHD and PTZOptics, Richards is the host of multiple online shows that feature his work on YouTube, Facebook, LinkedIn, and Twitch.

Paul is also the Chief Streaming Officer at StreamGeeks and teaches Udemy courses online to over 50,000 students. Course topics include live video production, online communications, and social media connectivity.

GLOSSARY OF TERMS

3.5mm Audio Cable: Male to male stereo cable, common in standard audio uses.

4K: A high definition resolution option (3840 x 2160 pixels or 4096 x 2160 pixels)

Application Program Interface (API): A streaming API is a set of data a social media network uses to transmit on the web in real time. Going live directly from YouTube or Facebook login uses their API.

Bandwidth - The range of frequencies within a given band, in particular that used for transmitting a signal.

Broadcasting - The distribution of audio or video content to a dispersed audience via any electronic mass communications medium.

Broadcast Frame Rates - Used to describe how many frames per second are captured in broadcasting. Common frame rates in broadcast include: **29.97fps** and **59.97 fps**.

Capture Card - A device with inputs and outputs that allow a camera to connect to a computer.

Chroma Key - A video effect that allows you to layer images and manipulate color hues [i.e. green screen]

Cloud-Based Streaming - Streaming and video production interaction that occurs within the cloud, therefore accessible beyond a single user's computer device.

Color Matching - The process of managing color and lighting settings on multiple cameras to match their appearance.

Community Strategy - The strategy of building one's brand and product recognition by building meaningful relationships with an audience, partner, and clientele base.

Content Delivery Network (CDN) - A network of servers that deliver web based content to an end user.

CPU (Central Processing Unit Usage) - the electronic circuitry within a computer that carries out the instructions of a computer program by performing the basic arithmetic, logical, control and input/output (I/O) operations specified by the instructions.

DAW - Digital Audio Workstation.

DB9 Cable - A common cable connection for camera joystick serial control.

Dynamic Host Configuration Protocol (DHCP) Router - A router with a network management protocol that dynamically sets IP addresses so the server can communicate with its sources.

Encoder - A device or software that converts a piece of code or info to then distribute it.

H.264 & H.265 - Common formats of video recording, compression, and delivery.

High Definition Multimedia Interface (HDMI) - A cable commonly used for transmitting audio/video.

High Efficiency Video Coding (HEVC) - H.264, one of the most common formats of video, MJPEG-H Part 2.

Internet Protocol (IP) Camera/Video - A camera or video source that can send and receive information via a network & internet.

IP Control - The ability to control/connect a camera or device via a network or internet.

Latency - The time it takes between sending a signal and the recipient receiving it.

Live Streaming - The process of sending and receiving audio and or video over the internet.

Local Area Network (LAN) - A network of computers linked together in one location.

Multicorder - A feature of streaming software that allows the user to record raw footage or a camera feed to a file separate from the stream output.

Network Device Interface (NDI®) - A software standard developed by NewTek to enable video-compatible products to communicate, deliver, and receive broadcast quality video in a high quality, low latency manner that is frame-accurate and suitable for switching in a live production environment.

NDI® Camera - A camera that allows you to send and receive video over your LAN.

NDI® | HX - NDI® High Efficiency, optimizes NDI® for limited bandwidth environments.

Network - A digital telecommunications network which allows nodes to share resources. In computer networks, computing devices exchange data with each other using connections between nodes.

NTSC - Video standard used in North America.

OTT Streaming (Over-The-Top) - When a media service bypasses conventional typical media outlets and distribution networks (ie. Facebook, YouTube, Twitch) to distribute content.

PAL - Analog video format widely used outside of North America.

PCIe Card - Enables high bandwidth communication between a device and the computer's motherboard.

PoE - Power over ethernet.

PTZ - Pan, tilt, zoom.

RS-232 - Serial camera control transmission.

Real Time Messaging Protocol (RTMP) - RTMP is a standard protocol for sending and receiving video. RTMP is used to deliver video streams over the public internet to CDNs such as Facebook or YouTube.

Real Time Streaming Protocol (RTSP) - Network control protocol for streaming from point to point.

Additional Online Courses:

Join over 50,000 other students who are learning how to use the power of live streaming! Take the following courses taught by Paul Richards for free by downloading the course coupon codes available at streamgeeks.us/start.

- **Facebook Live Streaming - Beginner**

This course will take you through basics of Facebook Live. The course has been updated twice and includes using Facebook Live Reactions.

- **YouTube Live Streaming - Beginner**

This course covers the basics of YouTube Live.. It also includes essential branding and marketing tips.

- **Introduction to OBS (Open Broadcaster Software)**

This course covers one of the world's most popular FREE live streaming software solutions. OBS is a great place to start live streaming for free.

- **Introduction to xSplit Software - Beginner**

This course takes you through xSplit which has more features than OBS but costs roughly \$5/month. Learn how to create impressive live productions and make your videos much faster with xSplit.

- **Introduction to vMix - Intermediate**

- The vMix Windows-based software tool will have you live streaming like the pros in no time. **Introduction to Wirecast - Intermediate**

Wirecast is the preferred software for many professional live streamers available for Mac and PC. **Introduction to NewTek NDI® - Intermediate**

NewTek's innovative IP video standard NDI® (Network Device Interface) will change the way you think about live video production. Learn how to use this innovative new technology for live streaming and video production system design.

- **Introduction to Live Streaming course - Beginner**

This course includes everything you need to start designing your show like a starter pack of course files including Photoshop, After Effects, and free Virtual Sets.

- **Introduction to Live Streaming - Intermediate**

This course focuses on more advanced techniques for optimizing your production workflow and using compression to get the most out of your processor. This course includes files for Photoshop, After Effects, and free Virtual Sets.

- **Helping Your Church Live Stream - Intermediate**

This course focuses on live streaming for churches and houses of worship. We tackle some of the specific challenges about live streaming in a house of worship.

- **How to Live Streaming A Wedding - Beginner**

This is a great course for anyone looking to start live streaming weddings. It was originally designed for wedding photographers to add a live streaming service to their existing portfolio of offerings.