Boundless Security Systems, Inc.

digital video security systems to deter, intervene and investigate

Comparison of Video Security System Architectures

- **Comparison Table, 2**
- **Digital Video Recorder (DVR)** has centralized control, like a wheel with hub and spokes. Proprietary hardware is used except for cameras. A central unit digitally captures and records analog video from CCTV cameras that are connected directly to it. A separate analog system selects, formats and distributes live video to CCTV video monitors. It provides only one digital video stream per camera, compromising deterrence, intervention and conviction.

  a) DVR Overview, 3
  b) DVR System Limitations, 4

- **Network Video Recorder (NVR)** has even more centralized control than a DVR. Proprietary hardware for input devices and video display on TV monitors are used with standard computer hardware for storage. A central unit records video from network cameras and network video servers that send large quantities of digital video to it via a local area network. A separate software system for live video requires each user to be in contact with the network cameras and video servers. It provides only one digital video stream per camera, compromising its ability to deter, intervene and convict terrorists and criminals.

  a) NVR Overview, 5
  b) NVR System Limitations, 6

- ***Boundless Security System™ with Storage Operating System™*** has fully distributed control, like a band of guerillas for the utmost survivability. It is based on the premise that things go wrong at the worst possible times, and that video security systems should survive it. Only standard computer hardware is used throughout, avoiding sole-source supply, expansion and maintenance problems, and providing a wide variety of housings for versatility. It is an enterprise-class system that handles virtually unlimited online disk storage (up to 1 PB) per network. It has fully distributed control of digital video capture, motion detection, MPEG-4 compression, recording and display, for the utmost reliability and performance. It provides three digital video streams per camera simultaneously, with different resolutions, frame rates and compression parameters. It satisfies competing needs for image quality, storage, communications and display-formatting for monitoring operations and the deterrence, intervention and investigation of terrorists and criminals. The combination of its ***virtual video processor*** at *every* display device for multi-camera display formatting, and its ***virtual video matrix switch*****,** provide **universal access** to live and recorded video simultaneously. Its core element is Boundless' ***Streaming DVR.*** Its multiple IP-video streams per camera provide low, video-on-demand network traffic and implement multiple network security zones, protecting the video system from Cyber attacks. It uses standard, CCTV cameras, and subframe-sequential, HDTV cameras for video input.

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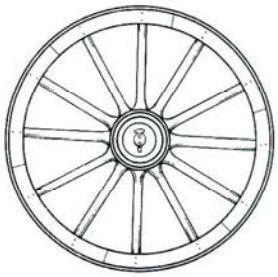
Comparison Table of Video Security System Architectures

	Digital Video Recorder (DVR)	Network Video Recorder (NVR)	*Boundless Security System™ with Storage Operating System™ / Streaming DVR*
Architecture	**Centralized control** with separate systems for live and recorded video. All cameras are wired to a DVR for recording. Only network traffic is video on demand when recorded images are accessed remotely. Video matrix switches, multiplexers and/or quad-processors are required to format and display live video locally at 30 fps / camera.	**Centralized control** with separate systems for live and recorded video. NVR server receives live video from network cameras and video servers via network for recording, flooding network with video. Multi-casting protocols used by some input de-vices to reduce traffic are subject to data loss within the network, requir-ing increased data to compensate.	Only system with **fully distributed**, redundant and fault-tolerant control. Has integrated live and recorded video. Compensates for transient and hard network and server over-loads and failures. Network traffic is limited to video on demand for remote access and within a network switch, except when storage pooling across the network is active.
Fault Toler-ance and Survivability	None due to centralized control, subject to single-point network and device failures	Limited (RAID storage) due to centralized control. Subject to trans-ient network and server overloads	Fully distributed, redundant and fault-tolerant control and access for utmost system survivability. Fault-tolerant storage without RAID cost.
Video Matrix Switch	If equipped, it is limited to selecting among the video inputs to a given DVR and to driving one monitor connected to the unit. Usually only one choice of multiple video inputs can be made at a time for multi-camera display. Access via network to live and recorded video is very limited.	An ethernet network provides a virtual, video matrix switch only for live video, which is handled separ-ately from recorded video. Users must obtain live video directly from video input devices, increasing network traffic when HTTP servers are used and compromising network security of video input devices.	**Universal access**: A fully integrated, digital, ***virtual matrix switch*** for both live and recorded video, with multiple resolutions, frame rates, data rates per camera. Boundless' ***Multi-Servers*** isolate users from video input devices to engineer network traffic and improve security of video input devices. Ideal for **Wi-Fi.**
Cameras Supported	Analog CCTV cameras, typ. up to 16 cameras per DVR but a few DVRs support up to 96 cameras	Digital network cameras, or network video servers for analog CCTV cameras; to 100's per network	Analog CCTV cameras with interlaced or progressive scan; to 1,000+ cameras per network
Video Streams per Camera	One, limiting image quality, storage, display and communications choices due to wide range of video needs for investigations, monitoring, and access via Internet and wireless display devices	One, limiting image quality, storage, display and communications choices due to wide range of video needs for investigations, monitoring, and access via Internet and wireless display devices	Three or more, with different resolu-tions, frame rates, quantizations and data rates to optimize image quality, storage, display and communications for: 1) investigations, 2) monitoring @ 30 fps, 3) emergency response
Frame Rate	Typ. about 5 fps/camera with only ¼ native camera resolution. but may be as high as 30 fps (recorded only)	HTTP servers provide a few fps / camera. RTP servers provide up to 30 fps / camera but flood network.	**Investigations** @5 fps/camera + **Monitoring** @30 fps/camera + **Em-ergency Resp.** @10 fps/camera(typ)
Video Compression	MJPEG or wavelets. Many DVRs record video with too low resolution and excessive compression, blurring images, to minimize storage	MJPEG for cameras that act as HTTP servers, or MPEG-4 for cameras that act as multi-casting, RTP servers	MPEG-4; different resolutions, frame rates, compression parameters and data rates for each stream for each camera meet competing needs
Online Disk Storage	Usually 100's of GB but some units support a few TB. Excessive compression is often used with recording that is turned on only when there is "motion" (frame-to-frame changes) to stretch the storage duration. Systems with many cameras and high resolution and frame rate may have only a few days storage in TB's.	Usually 100's of GB, to a few TB within a server, or up to about 100 TB using an external Storage Area Network (SAN), but often with high cost and high power dissipation due to use of many very fast but relatively low density disks. Expansion and repair generally require the video system to be taken out of service.	Boundless' ***Storage Operating System™*** supports up to 1 PB of distributed, low-power, disk storage per network. All storage is combined by software into a single pool that can be expanded and repaired on the fly. Monitoring stream(s) can be deleted after a short period of time to reduce storage if desired.
Display Formatting	Limited. Multiple live images can be scaled, combined and shown on a video monitor wired to the DVR.	Limited due to high cpu require-ments at display device to decode, scale and display multiple high resolution and high frame rate video streams.	***Virtual video processor*** for each display, to 96 streams per monitor. Multiple resolutions per camera minimize display cpu burden. For HDTV, SDTV, PC, PDA displays.
Cyber Security	Users must access each video capture device, jeopardizing security,	Users must communicate with video input devices, jeopardizing security.	Provides multiple network security zones that protect core network.
Hardware	Proprietary	Mix of proprietary and standard	Non-proprietary throughout
Other	Limited number of audio and alarm inputs, and PTZ outputs from each DVR	Many input devices handle audio, video, alarm inputs, control outputs, and PTZ control. RTP servers may continue to send video to users who no longer want it, wasting capacity.	***Streaming DVR*** handles audio, video, access control and PTZ / ASCII data. ***Video Player*** software is designed for integration into third-party software systems.

Notes: fps - frames per second, HTTP - Hyper Text Transfer Protocol, RTP - Real Time Protocol

1a) Digital Video Recorder (DVR)



Multiple analog CCTV cameras are cabled to central video switching, scaling, recording and display equipment. A **central control** architecture is used. Separate equipment for monitoring and recording is required. Viewing at 30 fps/camera is limited to monitors wired to the switch. Video recording frame rate, resolution and quality are often low to reduce compression and storage cost. Motion detection often controls recording to stretch storage duration but at the risk of missing data. The ability to view multiple live images at the same time on one screen is limited.

Central control of video capture, recording, display formatting, and distribution

Analog CCTV Camera

One analog video signal on each coax cable

All video being recorded and displayed must flow through here (the "HUB")

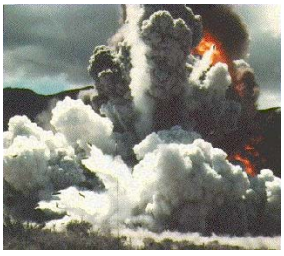
DVR

Digital Video Recorder for video capture and recording, and Video Matrix Switch or Multiplexer for local, live video

LAN cable

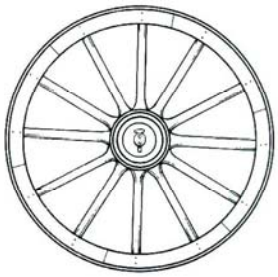
Analog Video Monitor

Ethernet Switch for network access



Loss of the central Video Matrix Switch or Multiplexer due to its failure or a catastrophe causes loss of viewing and recording of all cameras connected to it. Loss of a DVR causes loss of recording of all cameras connected to it. The DVR is often connected to a LAN for remote access, but the ability to view live or recorded video over the LAN and Internet is very limited.

DVR System Limitations



Central control of video capture, recording, display formatting, and distribution

Analog CCTV Camera

One analog video signal on each coax cable, up to 200m

All video being recorded and displayed must flow through here (the "HUB")

DVR

LAN cable; the only DVR traffic is video on demand

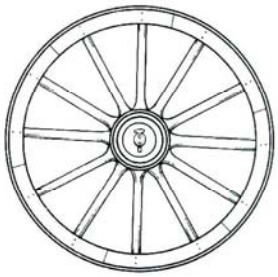
Ethernet Switch for network access

Analog Video Monitor

A Digital Video Recorder is combined with an internal or external Video Matrix Switch or Multiplexer to route live video from cameras to monitors, and to form one screen from the images from multiple cameras. Any hard drive failure causes DVR failure. Multiple DVR's cannot pool their storage, reducing storage duration. Adding or replacing disks takes the unit out of service unless hot-swappable disks are used.

2a) Network Video Recorder (NVR)

Multiple LAN Cameras and LAN Video Servers send compressed digital video to a central File Server with internal or external storage for recording. A **central control** architecture is used. Frame rates are low and erratic, and image resolutions are low if JPEG compression is used. MPEG-4 gives better images with less data but commonly used, multi-casting network protocols lose data and require additional data to compensate for data loss, increasing file size and network traffic.



Central control of recording

Video Cable

LAN Camera

PC displays live video from LAN Cameras or LAN Video Servers, or recorded video from File Server

Analog CCTV Camera

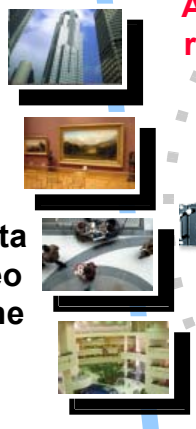
LAN Video Server

NVR

LAN cable

All video being recorded must flow through here (the "HUB")

SAN Cable



Multiple high data rate, digital video streams flood the network

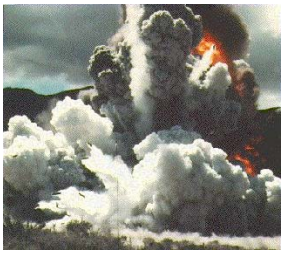
File Server (Control Unit)

Storage Area Network (SAN)

Ethernet Switch

Internet

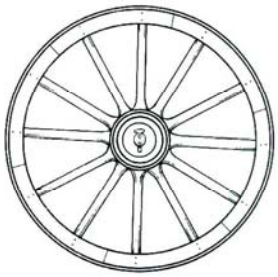
Router/Firewall



Loss of the central File Server or Storage Area Network due to its failure, network failure or catastrophe causes loss of recording of all cameras sending video to it. Loss of one LAN cable or Ethernet Switch may affect many cameras. Only one digital video stream per camera, with one resolution, frame rate and quantization, severely limits storage, display and communications choices.

2b) Network Video Recorder (NVR)

NVR System Limitations



Central control of recording

Video Cable

LAN Camera

PC displays live video from LAN Cameras or LAN Video Servers, or recorded video from File Server, but has difficulty decoding and displaying multiple "4CIF" streams at high frame rate due to high computation required

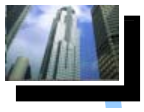
Analog CCTV Camera

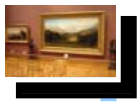
LAN Video Server

NVR

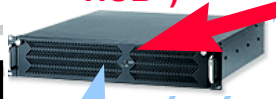
LAN cable up to 100m

All video being recorded must flow through here (the "HUB")





SAN Cable



File Server (Control Unit)

A large volume of digital video from each camera creates high network traffic. The popular move from "1CIF" to "4CIF" resolution causes inter-laced motion artifacts unless new progressive scan cameras are used.

Storage Area Network (opt.): high capacity (terabytes) but high power dissipation and high cost due to high speed needed to record many video streams at once with high data rates

JPEG is impractical for full resolution and frame rate video because sharp images need no more than 10:1 compression, requiring a hefty 16 Mbps/camera (approx. 170 GB / camera / day !)

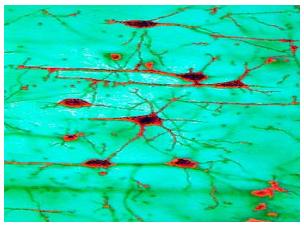
Ethernet Switch

Router/Firewall

Wavelet compression gives smoother, more appealing images than JPEG at high compression, but loses details

Internet, typ. only 128 to 256 Kbps (DSL or cable) to 1.5 Mbps (T1) upload speed, limiting remote viewing, especially when Real Time Protocols are used by LAN Cameras & Servers

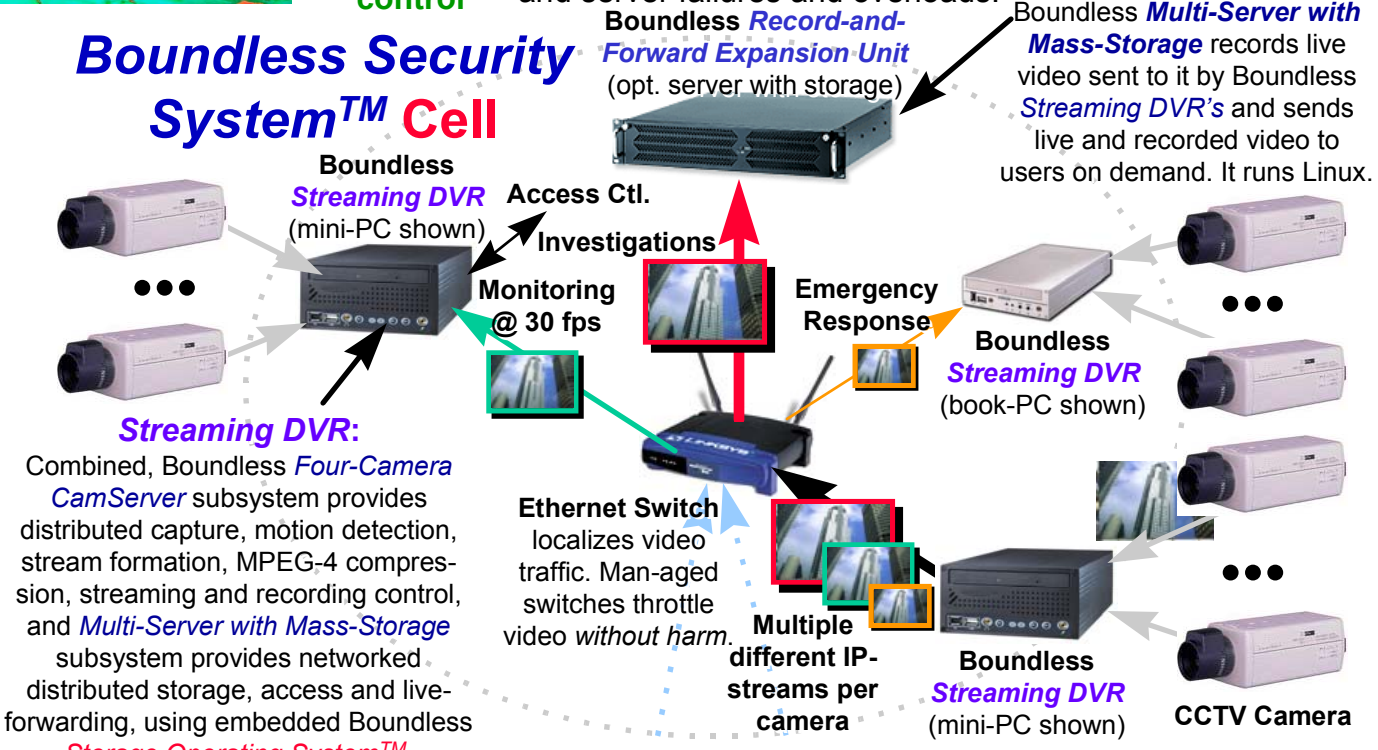
3a) Boundless Security System™ with Storage Operating System™



Fully distributed, fault-tolerant, cellular, redundant control

It's all about control. Boundless' fully distributed, cell-like control architecture provides fault-tolerant, redundant, survivable, reliable recording and live video @ 30 fps/camera. The system acts like multiple, independently managed but cooperating bands of Guerillas that quickly regroup and recover from temporary and permanent problems. The protocols used ensure reliable, MPEG-4 recording and smallest files despite transient and permanent, network and server failures and overloads.

Boundless Security System™ Cell



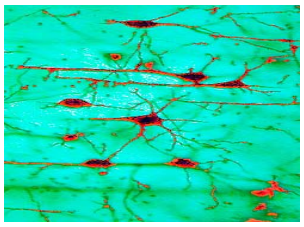
Each Boundless *Streaming DVR* creates multiple digital video streams per camera simultaneously, with different resolutions, frame rates and compression parameters. These streams satisfy competing needs for image quality, storage, communications and display-formatting for investigations, deterrance and intervention. Each Boundless *CamServer* is a master and controls recording by sending its IP-video streams to a co-located and/or one or more external Boundless *Multi-Servers* (slaves) for recording and live-forwarding, and continually validating proper recording. Non-proprietary computer hardware is used throughout, avoiding sole-source supply, expansion and maintenance problems, and providing a wide variety of housings for versatility.

Display devices and other *Boundless Security System™* cells

Router / Firewall — **Internet**

Boundless' ***Storage Operating System™*** combines all hard disks in all Boundless ***Multi-Servers*** on a LAN into a vast, seamless pool of storage (to 1 PB) for efficient use, and ease of repair and expansion. Boundless ***CamServers*** create multiple different digital video streams per camera, satisfying competing needs for image quality, storage, communications and display. Low, video-on-demand network traffic between ***Boundless Security System™*** cells enables reliable, wireless network (**Wi-Fi**) use between security cells, display devices and the Internet.

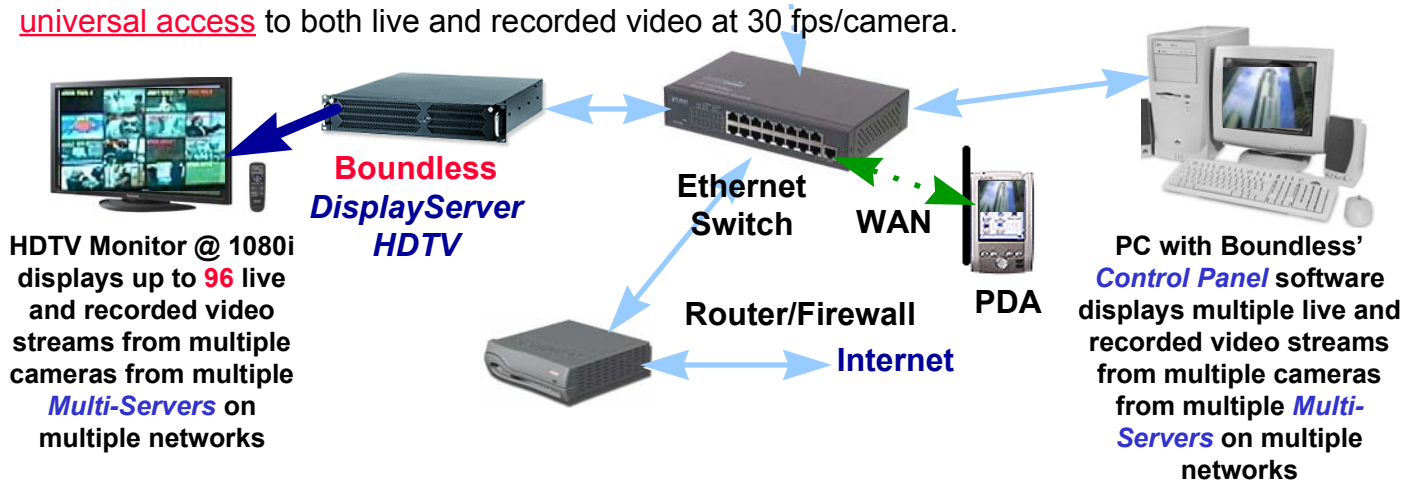
3b) Boundless Security System™ with Storage Operating System™



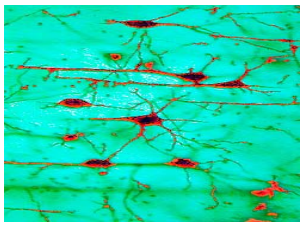
Fully distributed, fault-tolerant, cellular, redundant control

Boundless Supports Multiple Types of Video Displays

Multiple digital, IP-video streams, with different resolutions, frame rates, compression parameters and data rates, are provided simultaneously for each camera. These streams provide many display choices by minimizing the CPU burden of the display device to obtain, decode and display live and recorded video. The streams also minimize the communications requirements to view live and recorded video remotely, via the Internet, and via wireless networks. Boundless' unique combination of a *virtual video processor* at every display device, for efficient, independent, multi-stream display formatting, and enhanced *virtual video matrix switch,* provides universal access to both live and recorded video at 30 fps/camera.



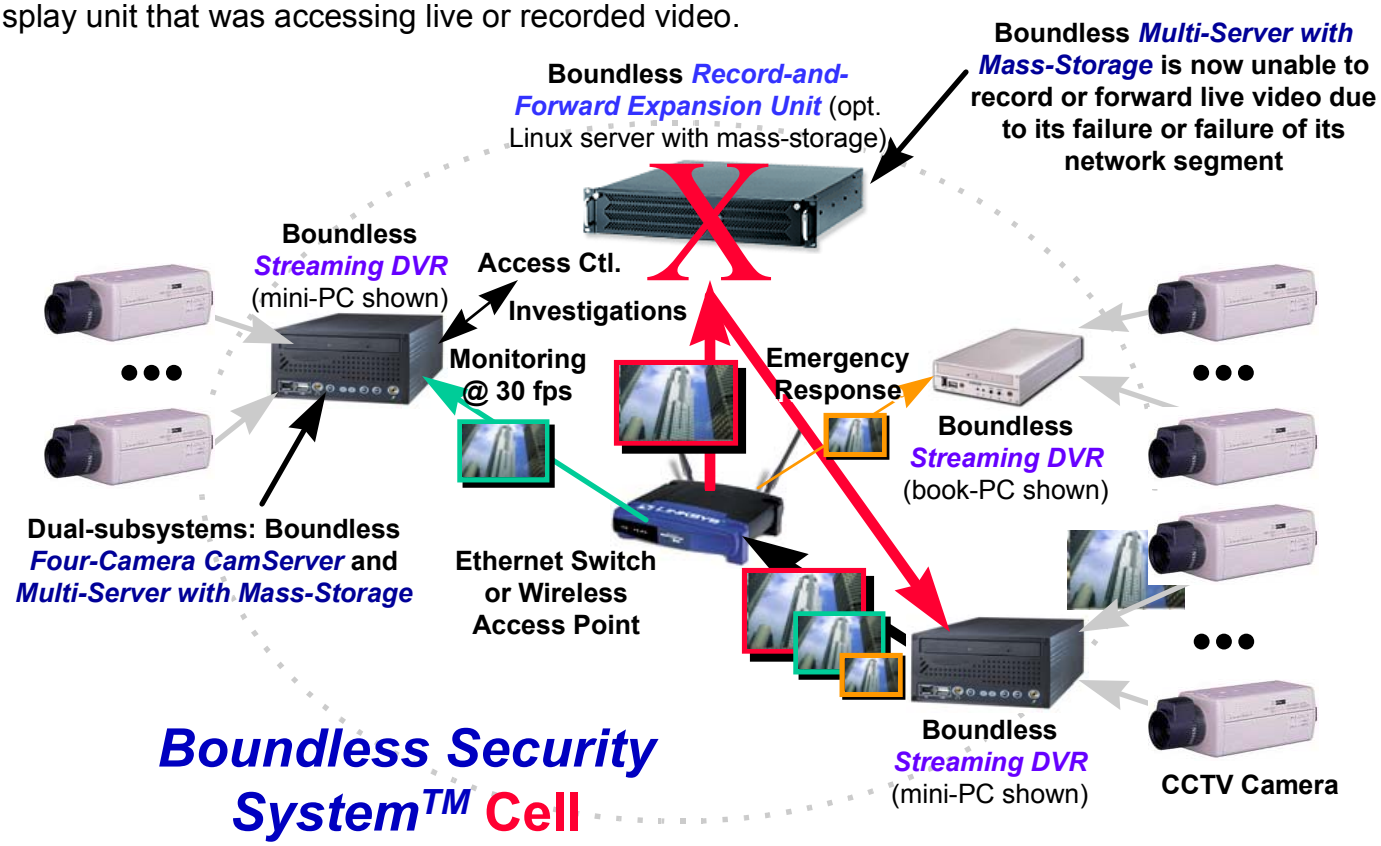
3c) Boundless Security System™ with Storage Operating System™



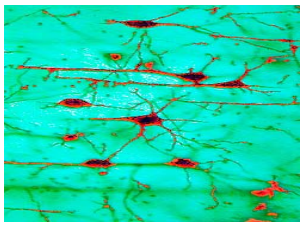
Fully distributed, fault-tolerant, cellular, redundant control

Boundless Automatically Recovers from Server Faults

If a Boundless *Multi-Server with Mass-Storage,* or its network segment, fails, or its storage is full, every Boundless *Streaming DVR* sending data to it detects the problem within seconds, redirects the video to an alternate *Multi-Server*, which may be co-located within the *Streaming DVR,* and resends the video that was briefly lost. The display of live video is resumed using the new *Multi-Server.* Error reports are sent by every affected *Streaming DVR* and by every display unit that was accessing live or recorded video.

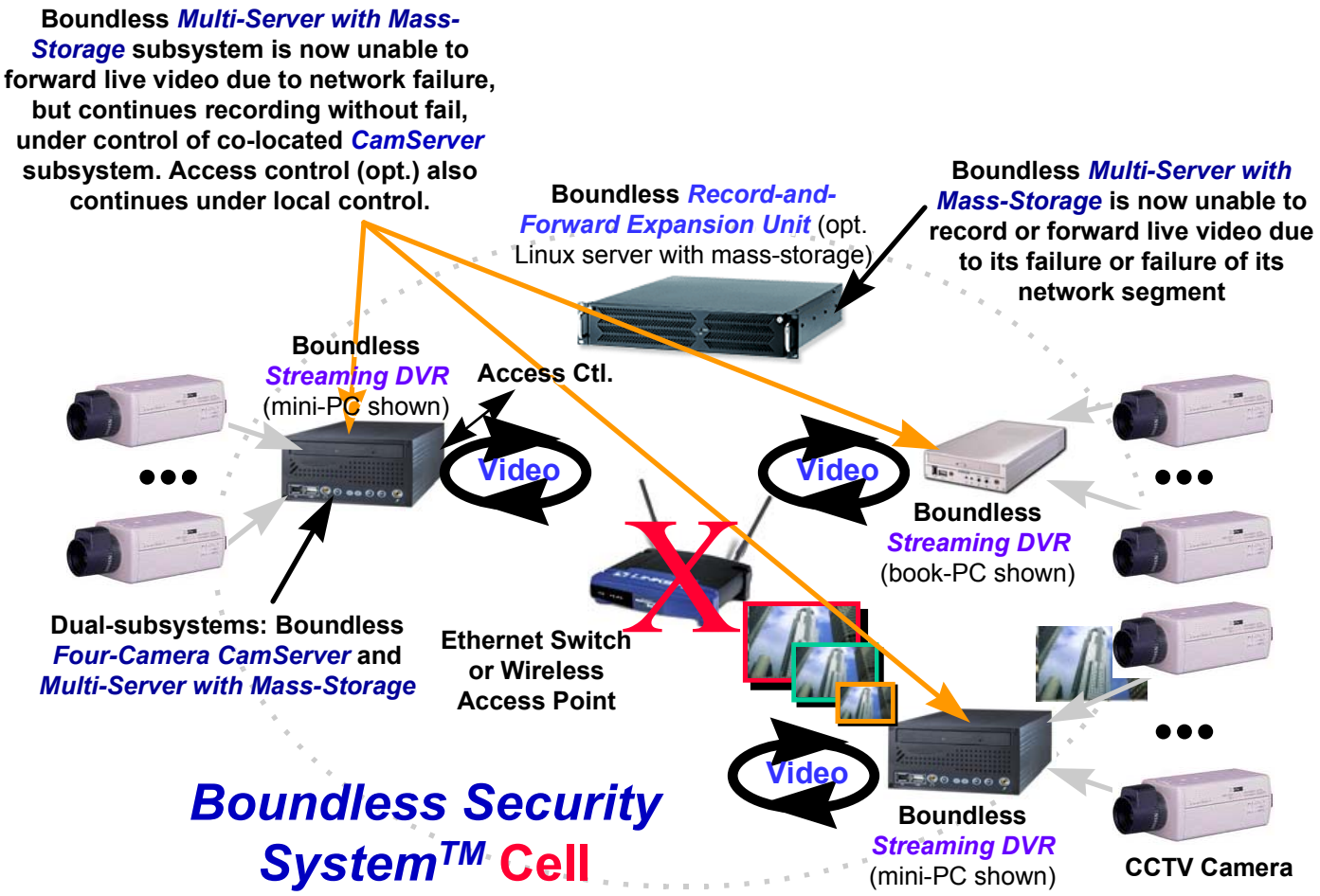


3d) Boundless Security System™ with Storage Operating System™



Fully distributed, fault-tolerant, cellular, redundant control

Boundless Automatically Recovers from Network Faults



If the ethernet switch, or the network segment a Boundless *Streaming DVR* is using to access it, fails, the Boundless *Streaming DVR* reroutes its IP-video streams to a co-located Boundless *Multi-Server with Mass-Storage* within seconds. Any video that was briefly lost is re-sent internally and recorded. Live viewing of the affected cameras via the network is lost until the network is restored, but recording continues without interruption. Error reports are sent by every affected, remote *Streaming DVR* and every display unit that was accessing live or recorded video from the affected cameras.

- End