



Boundless Security Systems, Inc.

sharper images with better access and easier installation



Woman-Owned
Small Business

Tutorial: Generations of Video Surveillance Systems

**An architectural analysis of six generations
of video surveillance systems, the three
most- recent being IP-based.**



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Security System Generations

- Video security systems can be classified into generations by the way:
 - video flows through the system, how...
 - live video moves from cameras to users and recording devices
 - recorded video moves from storage to users
 - the system is controlled, how...
 - recording and mass-storage are managed
 - access to live and recorded video is managed
 - system reconfiguration, if any, is done

Surveillance System Generations

G1: Time-Lapse Video Cassette Recorder System

G2: Digital Video Recorder System

G3: PC-based Digital Video Surveillance System

G4: Web-Serving LAN Camera System (1st generation, IP-based digital video security system, uses HTTP)

G5: Streaming LAN Camera System (2nd generation, IP-based digital video security system, uses RTP)

G6: *Boundless Security System*TM (3rd generation, IP-based, ultra low bandwidth, fully converged, digital video surveillance system, uses Boundless' *Storage Operating System*TM software)

IP = Internet Protocols, HTTP = Hyper Text Transport Protocol, RTP = Real Time Protocol

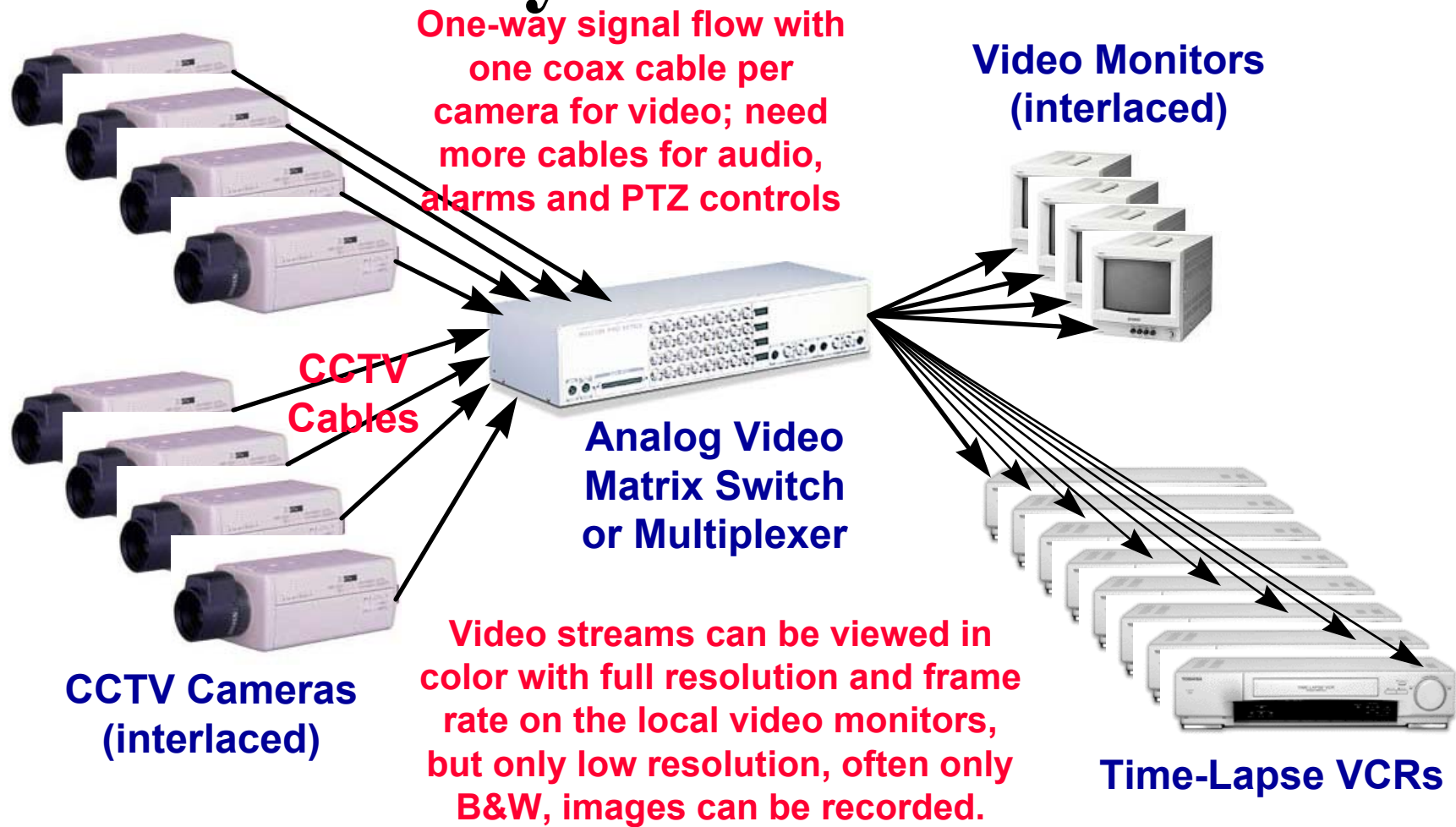
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G1: Time-Lapse Video Cassette Recorder System



Many CCTV cameras, even older ones, have good images. The loss of quality in recorded images is usually caused by limitations in the recording system, not the cameras. The analog recorders trade storage duration for image quality, losing image quality.

G1: Time-Lapse Video Cassette Recorder System



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G1: Time-Lapse Video Cassette Recorder System

- **System Architecture**
 - analog interlaced CCTV cameras
 - analog video matrix switches or multiplexers
 - analog time-lapse video cassette recorder (VCR)
 - analog CCTV video monitors
- **Pros**
 - very inexpensive analog storage on video tape
 - analog storage may provide better ability to recover images than some digital systems, which have non-linear artifacts from JPEG compression
 - inexpensive video display on CCTV monitors

G1: Time-Lapse Video Cassette Recorder System

- **Cons**

- labor-intensive: must remove, replace and store video tapes to increase storage
- video tape and recording heads wear out with use
- very poor recorded images, often black & white
- limited to one to a few cameras per VCR, with video dropouts when cameras are switched
- cannot view and record at same time
- no remote access to recorded video
- requires separate CCTV system to view live video
- failure of video matrix switch or recorder causes loss of recording of cameras connected to it
- 200m max. cable length unless other means used

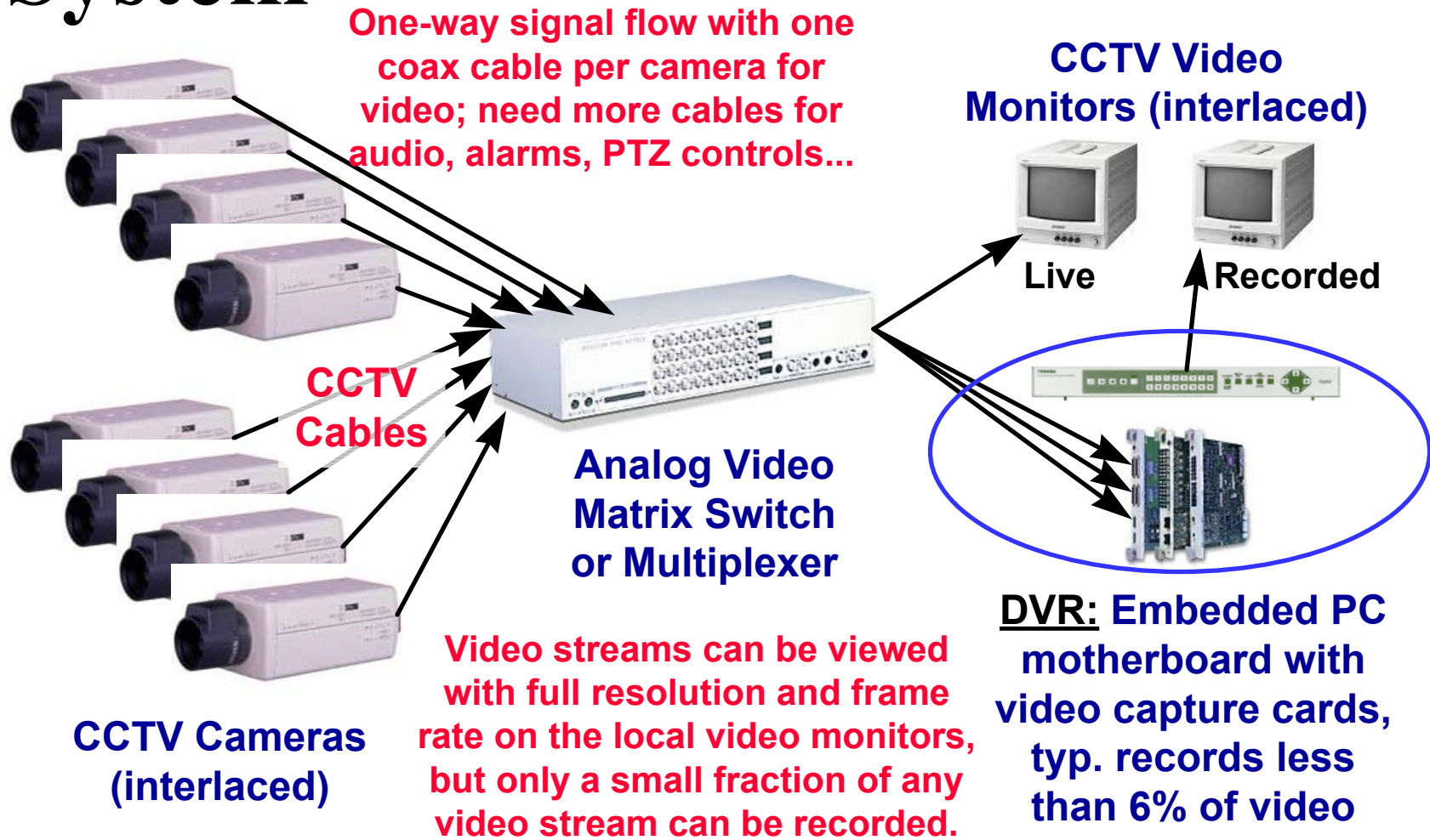
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G2: Digital Video Recorder System



Many CCTV cameras, even older ones, have good images. The loss of quality in recorded images is usually caused by limitations in the recording system, not the cameras. Video is usually captured with too-low resolution and compressed too much.

: G2: Digital Video Recorder System



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G2: Digital Video Recorder System

- **System Architecture**
 - analog CCTV cameras with interlaced scan
 - video matrix switches or multiplexers
 - digital video recorder (DVR)
 - digitize selected video stream
 - digitally compress selected frames with JPEG (typ.)
 - digitally store compressed images to hard drive
 - requires int. or ext. mux for *each*, multi-camera view
 - analog interlaced CCTV video monitors for recorded video
 - separate analog CCTV system for 30 fps live video
 - connection to phone line or LAN and internet

G2: Digital Video Recorder System

- **Pros**
 - better quality recorded video than time-lapse VCR
 - digitally recorded video does not degrade with use
 - may support remote access digitally to recordings
 - inexpensive video display on CCTV monitors
- **Cons (cont. next slide)**
 - typically only 1 to 16 cameras per DVR
 - proprietary hardware gives maintenance problem
 - typ. intraframe-only compression, usually JPEG, gives limited compression and excessive artifacts when highest amount of compression selected; wavelet compression gives better (smoother) appearance at high compression but loses details

G2: Digital Video Recorder System

- **Cons, cont.**
 - video is usually recorded with CIF resolution (352 x 240), only 25% of camera resolution
 - limited video recording capacity, typically total of 30 to 120 CIF frames/s divided among all cameras
 - recording capacity decreases as remote access to recorded video increases due to cpu loading
 - limited amount of hard disk storage
 - often need separate, CCTV system for live video
 - failure of DVR causes loss of use of all cameras
 - *single-user*, internal mux for multi-camera view
 - **lack of interoperability between vendors**

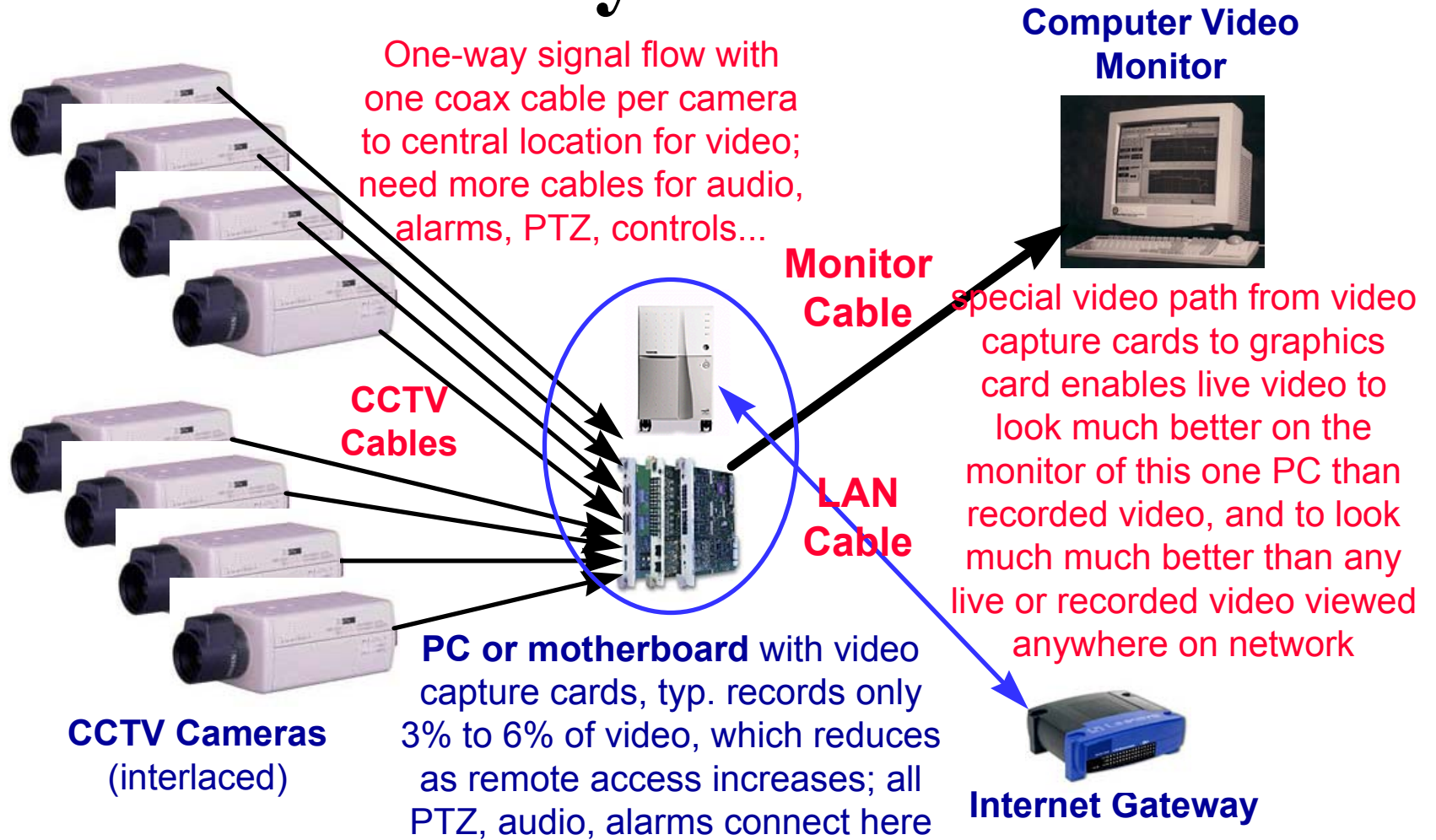
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G3: PC-based Digital Video Surveillance System



Many CCTV cameras, even older ones, have good images. The loss of quality in recorded images is usually caused by limitations in the recording system, not the cameras. Video is usually captured with too-low resolution and compressed too much.

G3: PC-based Digital Video Surveillance System



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G3: PC-based Digital Video Surveillance System

- **System Architecture**
 - analog interlaced CCTV cameras
 - PC with video capture cards
 - select one or more video streams
 - reduce image resolution and digitize selected frames
 - compress selected frames with JPEG or other
 - store compressed images to hard drive as files
 - make files available on LAN via built-in Web server
 - provide special high-speed path from video capture to video display for live images (not viewable elsewhere)
 - PC video monitor
 - connection to phone line or LAN and Internet

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G3: PC-based Digital Video Surveillance System

- **Pros**

- handle more video inputs than DVR, typ. 8 to 16
- usually able to record more frames/s than DVR
- better able to handle audio and PTZ than DVR
- remote access via Internet usually standard
- new file per video frame and networked access via HTTP adapts to varying communication rates
- easier on eyes to view video on non-interlaced PC video monitor than on interlaced CCTV monitor but computation to convert video from YUV camera format to RGB monitor format required

G3: PC-based Digital Video Surveillance System

- **Cons (cont. next slide)**
 - video is usually recorded with CIF resolution (352 x 240), only 25% of resolution of a camera's frame
 - limited video recording capacity, typ. total of 60 to 120 CIF frames/s divided over all cameras, only enough to record 1/2 to 1 camera if full resolution and frame rate were captured for a single camera
 - recording capacity decreases as remote access to live & recorded video increases due to cpu loading
 - best live video limited to PC with capture cards
 - limited internal storage duration / disk capacity

G3: PC-based Digital Video Surveillance System

- **Cons, cont.**
 - **typ. intra-frame-only compression, usually JPEG, gives limited compression and excessive artifacts when highest amount of compression selected; wavelet compression gives better (softer) appearance at high compression but loses details**
 - **limited number of audio, alarm and PTZ channels**
 - **PC failure causes loss of recording of all cameras**
 - **reliability problems due to running many tasks**
 - **often need separate, CCTV system for live video**
 - **proprietary hardware and software design create service and interoperability problems**

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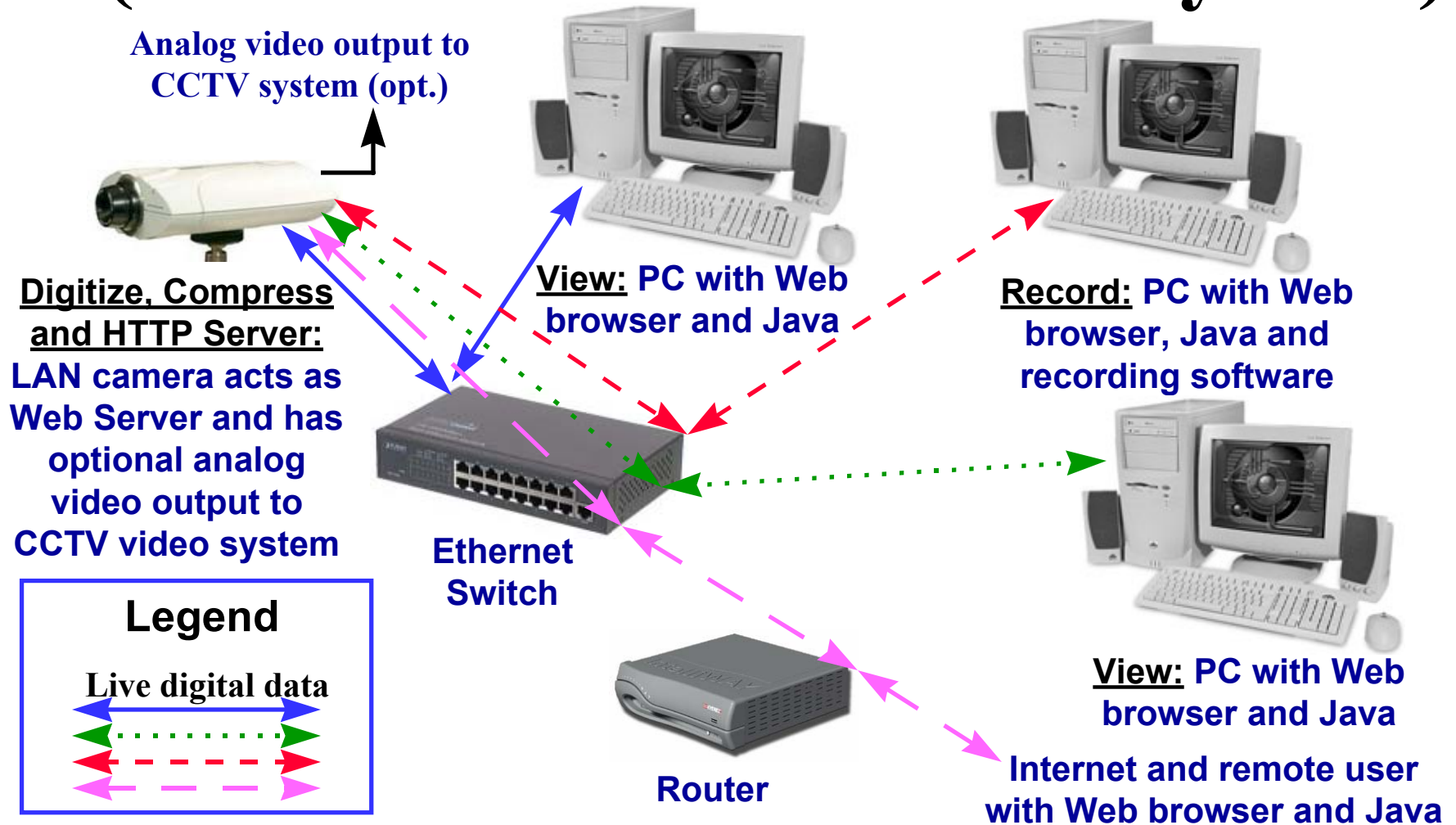
G4: Web-Serving LAN Camera (1st Generation IP-based System)



Easy access to live video from networked cameras and networked video servers but at low frame rate and resolution, using a Web browser that supports Java. High data rates limit their use.

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G4: Web-Serving LAN Camera (1st Generation IP-based System)



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G4: Web-Serving LAN Camera (1st Generation IP-based System)

- **System Architecture**
 - digital video input units
 - Web-serving LAN camera, and/or LAN video server for CCTV cameras, with RISC processor for all processing
 - select a video stream
 - reduce image resolution and digitize selected frames
 - compress selected frame with JPEG and store in *new* file
 - make each file available on LAN via built-in Web server
 - ethernet switch
 - View: PC with Web browser and Java
 - Record (opt.): PC with Web browser, Java and recording software
 - ethernet router and connection to Internet

G4: Web-Serving LAN Camera (1st Generation IP-based System)

- **Pros**

- easily provide occasional video images via LAN
- handles different access speeds simultaneously by dropping varying numbers of frames
- view with any Web browser that supports Java
- able to switch and route packets of video data inexpensively using ethernet switches
- able to use inexpensive ethernet infrastructure to transport video data packets long distances
- able to have alarms and PTZ at every camera
- resolution not limited to NTSC/PAL CCTV if very low frame rate and/or high data rate acceptable

G4: Web-Serving LAN Camera (1st Generation IP-based System)

- **Cons**

- very low resolution and low frame rate images
- LAN camera processor easily overloaded by users
- floods network with video at high frame rates
- NTSC @ 30 fps with JPEG @ 10:1 needs 25 Mbps
- recorded video, if any, and live video not available from single source
- Java for decoding, YUV → RGB, and displaying compressed images is very inefficient and slow
- requires CCTV system to view quality live video
- camera may digitally zoom or pan to reduce image size and data rate but only for a single-user
- max. length of LAN cable less than for video cable

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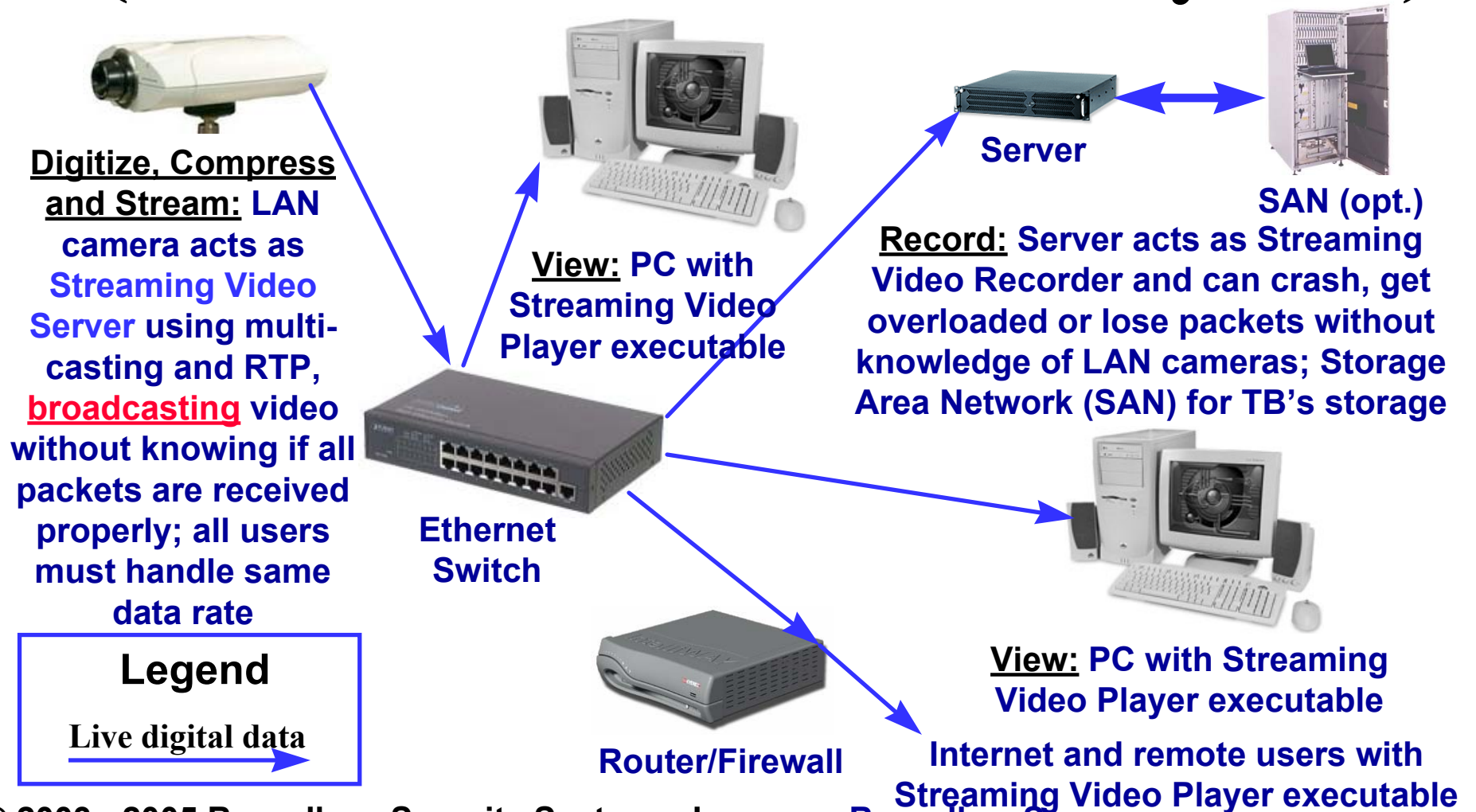
G5: Streaming LAN Camera (2nd Generation IP-based System)



Better video quality than Web-serving networked cameras and video servers by using better compression, streaming (Real Time Protocol with multi-casting), and an executable video player. Use of video streaming protocols require masking errors in video transmission.

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G5: Streaming LAN Camera (2nd Generation IP-based System)



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G5: Streaming LAN Camera (2nd Generation IP-based System)

- **System Architecture**
 - **digital video input units**
 - Streaming LAN camera, and/or LAN video server for CCTV cameras, with DSP and RISC chips for processing
 - select one of several video inputs if more than one unless multiple DSP's are used for multiple inputs
 - reduce image resolution and digitize selected frames
 - compress selected frames with MPEG-4 or other
 - stream video to LAN via built-in multi-casting server
 - **ethernet switch**
 - **fast Windows PC with video player software**
 - **PC with recording software and mass storage**
 - **ethernet router and connection to Internet**

: G5: Streaming LAN Camera (2nd Generation IP-based System)

- **Pros**

- better image quality and lower network traffic than Web-Serving camera by using interframe compression, e.g., MPEG-x, not intraframe, e.g., JPEG
- able to switch and route packets of video data inexpensively using ethernet switches
- able to use inexpensive ethernet infrastructure to transport video data packets long distances and to simplify installation
- able to have binary alarm inputs/outputs, PTZ controls and audio input at every camera/server
- resolution not limited to NTSC/PAL CCTV

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G5: Streaming LAN Camera (2nd Generation IP-based System)

- **Cons (cont. next slide)**

- networks lose packets and perfect recording not possible because reliable network transmission not possible with RTP and multi-casting
- video dropouts due to transient network and server overloads; each packet loss affects multiple frames, especially if a “key frame” is damaged
- data rate increases due to increased frequency of key frames to compensate for network data loss
- throttled and WiFi network segments not suitable
- proprietary video input devices = service problems
- live/recorded video not available from one source
- fast Windows PC needed to receive, decode and display video with high frame rate

G5: Streaming LAN Camera (2nd Generation IP-based System)

- **Cons**

- temptation to use centralized recording with very high capacity storage area networks (SAN's)
- recording server burdened by need to decode and break video streams into files at optimum points
- all recipients need same connection speed for a given video stream due to multi-casting; viewers on Internet may force reduction of video quality on local users to reduce data rate
- need to update multi-casting address list to add/delete recipients is network security problem
- multi-casting list reduces packet data capacity
- excessive network traffic when multi-casting list includes recipients who no longer want video

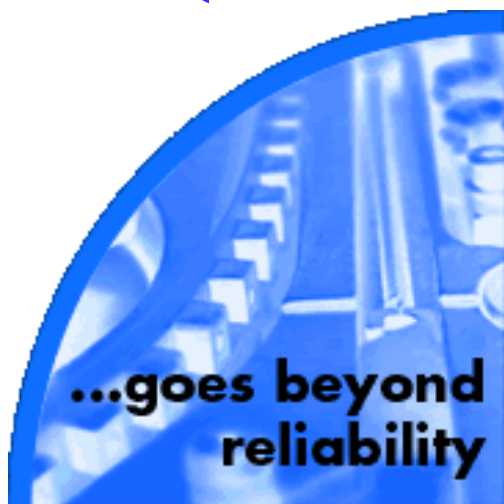


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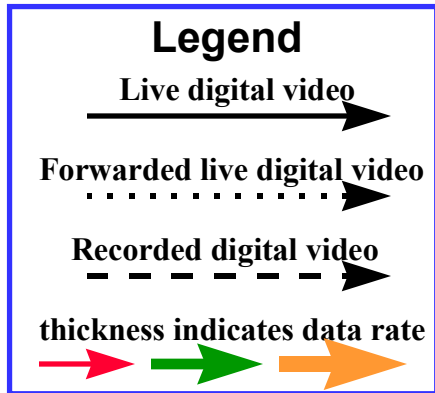
G6: *Boundless Security System*TM **(3rd Generation IP-based System)**



*Works like clockwork.*TM

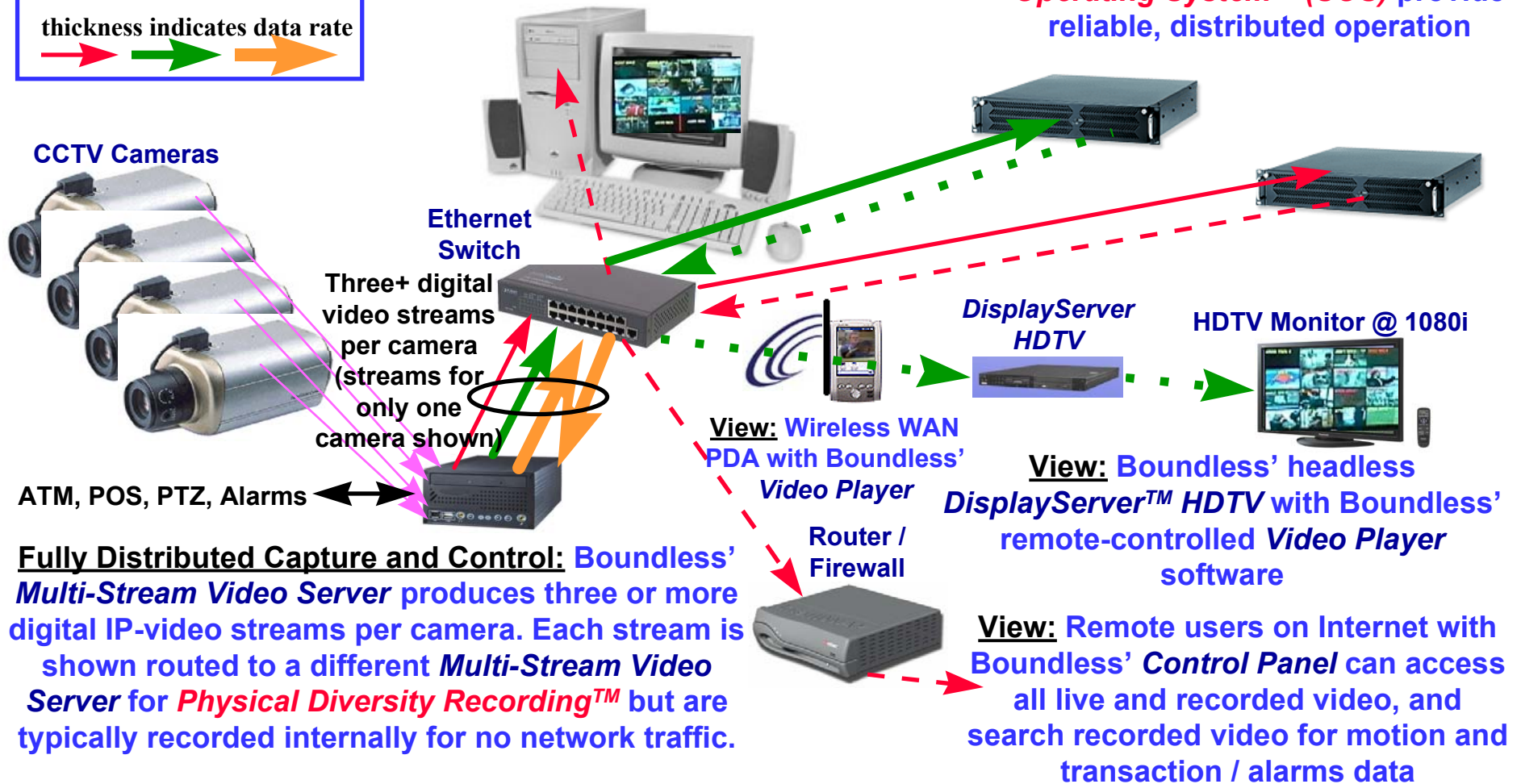
Ultra low bandwidth, fault-tolerant, redundant, fully converged, inherently-networked, enterprise-class, digital video surveillance system. It is designed on the premise that things go wrong at the worst possible times, and that the video surveillance system should cope with it. *Live Alerts* minimize monitoring. Running third-party applications at the point of capture provides audio and video analytics. The Internet protocols used assure error-free video transmission.

: G6: *Boundless Security System™* (3rd Gen. IP)



View: Windows PC with Boundless' multi-threaded *Control Panel* can display live and recorded video from multiple cameras from multiple sites simultaneously; all users can make their own selections independently

Record and Live-Forward: Boundless' Linux-based *Multi-Stream Video Servers* with Boundless' fully distributed, redundant, fault-tolerant, *Storage Operating System™ (SOS)* provide reliable, distributed operation



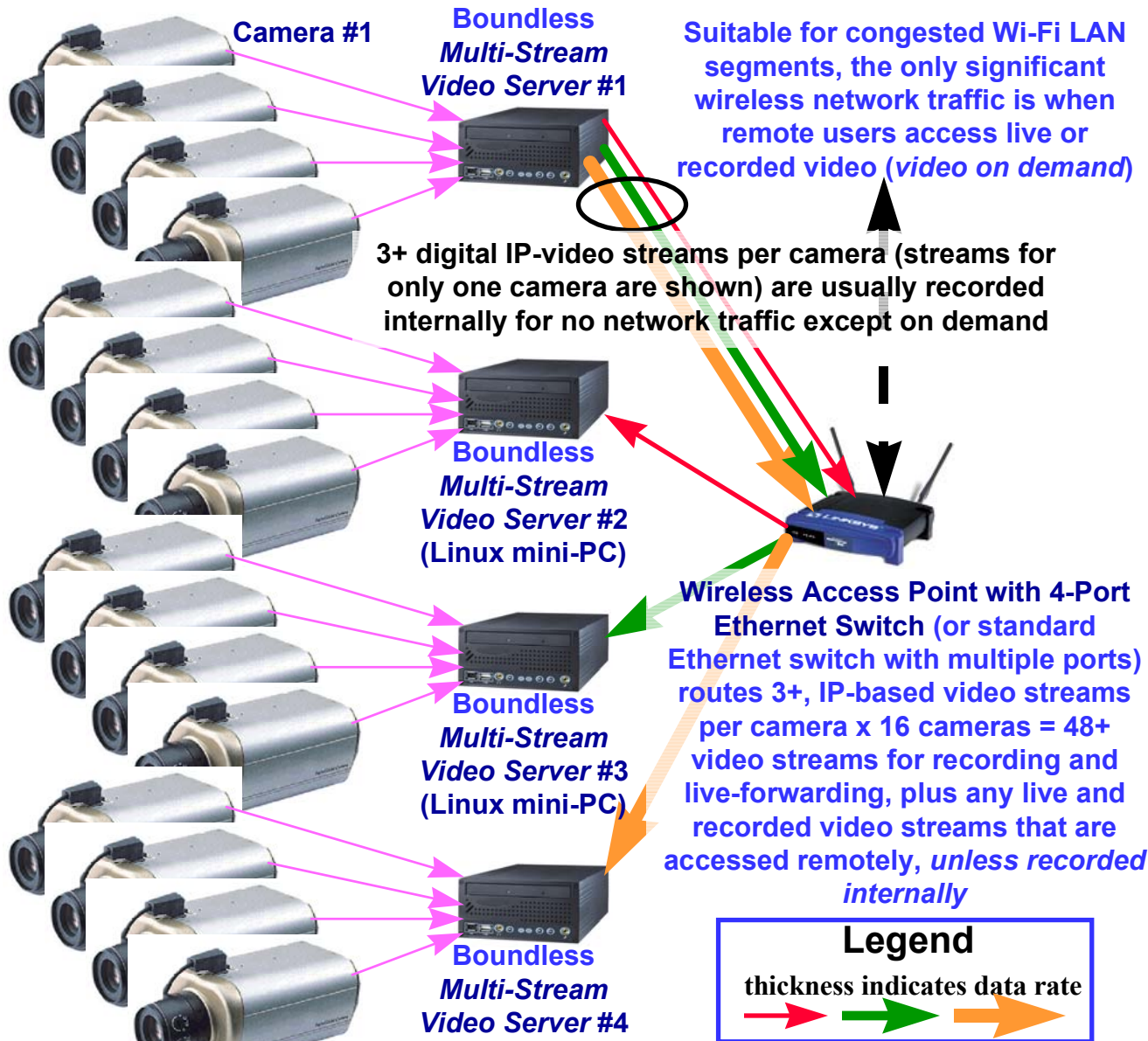
Fully Distributed Capture and Control: Boundless' *Multi-Stream Video Server* produces three or more digital IP-video streams per camera. Each stream is shown routed to a different *Multi-Stream Video Server* for *Physical Diversity Recording™* but are typically recorded internally for no network traffic.

View: Wireless WAN PDA with Boundless' *Video Player*

View: Boundless' headless *DisplayServer™ HDTV* with Boundless' remote-controlled *Video Player* software

View: Remote users on Internet with Boundless' *Control Panel* can access all live and recorded video, and search recorded video for motion and transaction / alarms data

: G6: Fault-Tolerant Storage and Low, Video-on-Demand Traffic in *Boundless Security System*TM 32



- The *capture* subsystem of the Boundless *Multi-Stream Video Server* creates 3+ IP-based video streams for Camera #1. It sends them to the internal record, forward and search subsystem, or to an Ethernet switch, which routes them to other Boundless *Multi-Stream Video Servers* for recording, forwarding and searching.
- The record, forward and search subsystem of the Boundless *Multi-Stream Video Server #2* records, forwards and searches the IP-based, *Situation Assessment Stream* for Camera #1 (and others).
- The record, forward and search subsystem of the Boundless *Multi-Stream Video Server #3*, records, forwards and searches IP-based, *Monitoring Stream* (30 fps / camera) for Camera #1 (and others).
- The record, forward and search subsystem of the Boundless *Multi-Stream Video Server #4*, records, forwards and searches IP-based, *Investigations Stream* for Camera #1 (and others).

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G6: *Boundless Security System*TM
(3rd Generation IP-based System)

- **System Architecture (cont. next slide)**
 - *fault-tolerant, fully scalable and distributed with complete control from its “edge” or perimeter*
 - **digital video input and storage-control units**
 - *Multi-Stream Video Server* for four CCTV cameras (no mux) produces three or more resolutions, frame rates and quantizations (3+ IP-based video streams) *per camera*
 - digitize audio and video, and capture event information
 - compress video with MPEG-4 Simple Profile
 - encapsulate in ***Storage Operating System*TM** protocols
 - encapsulate in Internet protocols and reliably send to one or more *Multi-Stream Video Servers* for recording and live-forwarding, or store internally for no network traffic
 - provide ***Physical Diversity Recording*TM** of multiple streams

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G6: *Boundless Security System*TM **(3rd Generation IP-based System)**

- **System Architecture, cont.**
 - ultra low bandwidth, multi-function, ***Multi-Stream Video Server*** provides video-on-demand
 - ethernet switches, routers and Internet connection
 - Linux-based ***Multi-Stream Video Servers*** record, access, live-forward and search recorded video
 - ***Storage Operating System*TM** for vast (to 1 EB) on-line storage without server, disk, partition limits
 - fast Windows PC with multi-threaded ***Video Player***
 - ***DisplayServer HDTV*TM** accesses live and recorded video from ***Multi-Servers***, display on HDTV monitor

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G6: *Boundless Security System*TM (3rd Generation IP-based System)

- **Pros (cont. next slide)**

- **nonstop:** reliable recording ensured despite transient network and *Multi-Stream Server* overloads
- **fault-tolerant:** digital video input and control units detect faults in *Multi-Server(s)* they are using and automatically switch to alternate without data loss
- three image resolutions, frame rates and quantizations simultaneously for every camera (3 streams / camera), **optimize competing requirements** for:
 - investigations: full camera resolution, max. sharpness / min. quantization, medium frame rate = highest data rate
 - monitoring: med. res., med. quant., 10 to 30 fps/camera
 - situation assessment: lowest resolution, high quantization, 5 to 10 fps/camera = lowest data rate

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G6: *Boundless Security System*TM **(3rd Generation IP-based System)**

- **Pros, cont.**

- **three image resolutions, frame rates and quantizations simultaneously for every camera (3 streams / camera), *optimize diverse system requirements* for:**
 - **display formatting:** minimize display cpu load by selecting streams that best fit each screen layout without scaling
 - **storage duration:** separate storage retention policies for each recorded stream minimize storage requirements
 - **communications:** choose streams with optimum resolution and frame rate for viewing, reducing network traffic
- **combines video-on-demand, low network traffic of DVR's with superior connectivity, access, scalability, and ease of installation of IP-based systems**

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G6: *Boundless Security System*TM **(3rd Generation IP-based System)**

- **Pros, cont.**

- users can view multiple live and recorded streams on each screen independently of all other users
- low latency live and recorded video
- extremely high quality live and recorded video, able to record and live-forward all cameras all the time with multiple resolutions and frame rates
- virtually unlimited (to 1 EB per network) online distributed disk storage using Boundless' ***Storage Operating System*TM (SOS) software**, without limits of single server or storage area network (SAN)
- ***full storage virtualization*** for seamless access by **Control Panel** to vast amounts of recorded video

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G6: *Boundless Security System*TM **(3rd Generation IP-based System)**

- **Pros, cont.**

- **MPEG-4 enhanced-VBR (variable bit rate with not-to-exceed limit) recording reduces data rate as motion decreases but caps maximum data rate; no need for motion detectors to gate recording**
- ***network-friendly*, video traffic can be engineered and new network security options can be provided**
- **combined capture/recording/storage devices can produce no network traffic except when accessed**
- **non-proprietary hardware throughout avoids sole-source supply and maintenance problems, and provides multiple housings for versatility; sold with Boundless software installed and configured**

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G6: *Boundless Security System*TM **(3rd Generation IP-based System)**

- **Pros, cont.**

- **economical and low power**

- Boundless' storage is priced less per gigabyte than other online storage and includes record-and-forward server, and uses low power for less heat and improved reliability
- system-level solution provides *virtual video processor* at each display device, and *virtual digital matrix switch*

- ***Control Panel*** software is multi-threaded and efficiently accesses, decodes and displays live / recorded video from multiple cameras simultaneously, with multiple resolutions and frame rates, from multiple ***Multi-Stream Video Servers***, on multiple networks, on each PC and ***DisplayServer***

HDTV

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G6: *Boundless Security System*TM **(3rd Generation IP-based System)**

- **Pros, cont.**

- *Video Player* is a “portal” to *Boundless Security System*TM so all live/recorded audio/video/event data can be embedded in 3rd-party software easily, without borders, using run-time parameters; multiple instances are used by *Control Panel* software
- multiple alarm inputs/outputs, ATM / POS / PTZ, and audio input (opt.) at every *Multi-Stream Server*
- able to use inexpensive ethernet infrastructure to transport video data packets long distances and to simplify installation
- video-on-demand architecture and reliable network transmission enable use of Wi-Fi segments

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G6: *Boundless Security System*TM **(3rd Generation IP-based System)**

- **Pros, cont.**

- 24 live video streams at 3 fps/camera can be carried in a TOTAL uplink of less than 500 Kbps
- Multi-Stream Video Servers in the field withstand millions of Cyber attacks per month

- **Cons**

- new to market but numerous large sites are in continuous operation and the system has been running continuously for more than a year



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**Please check with vendors for latest
information. Information is believed
accurate but no liability for errors.**



The End

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