Fire and Security Systems

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- Basic principles

- Security systems

- CCTV systems

- Access control systems

- Burglar & intruder alarms

Functions of building automation system (BAS)

Fire & security

FIRE
Functionality
checks
Detector service
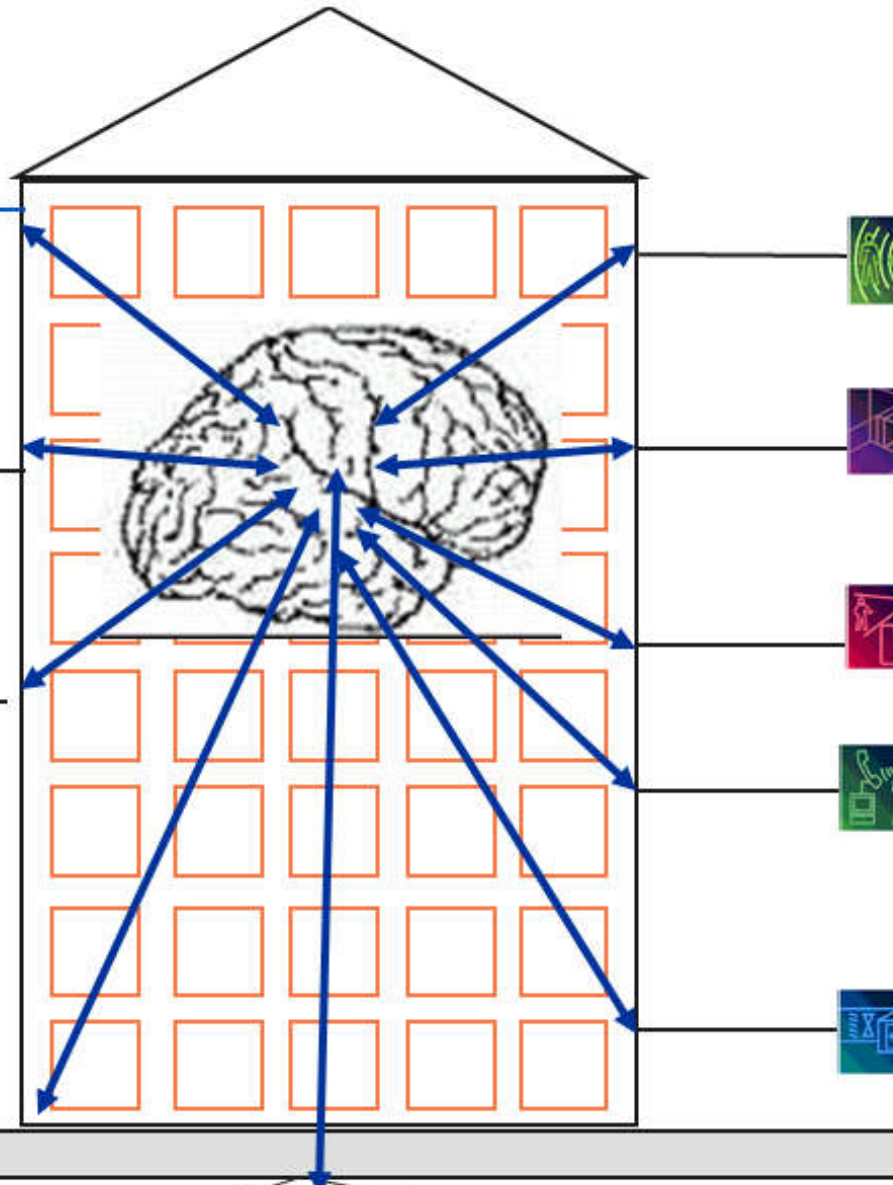Fire, Life, Safety

SECURITY
Doors
PIR
Integration

ACCESS
Doors
Buildings
Occupancy
Feed Forward

ENERGY
Utility Monitoring
(Elec/Water/Gas/Oil)
Tenant Building
Air/Water
Heat
Lighting
Back-up Generation

LIGHTING
Schedules
Occupancy Sensing

PEOPLE MOVERS
Breakdown
Maintenance
Traffic Performance

COMMUNICATIONS
Voice/Video/Data

24/7 Monitoring
Breakdown
Plant Tuning
Conditioned Monitoring
Car Park Utilisation

HVAC
Air-Handling Unit
Boilers
Pumps
Fans
Energy Control
Variable Air Volume
Air Quality

E   G   W

[Source: https://docplayer.net/5893734-Chapter-5-introduction-to-building-automation-system-bas.html]

Fire, security & other extra low voltage (ELV) systems in commercial buildings

Fire Alarm System

CCTV System

PA System

Digital Signage System

Access Control System

MATV/SMATV/IPTV System

PABX System

Human Barrier System

Car Parking System
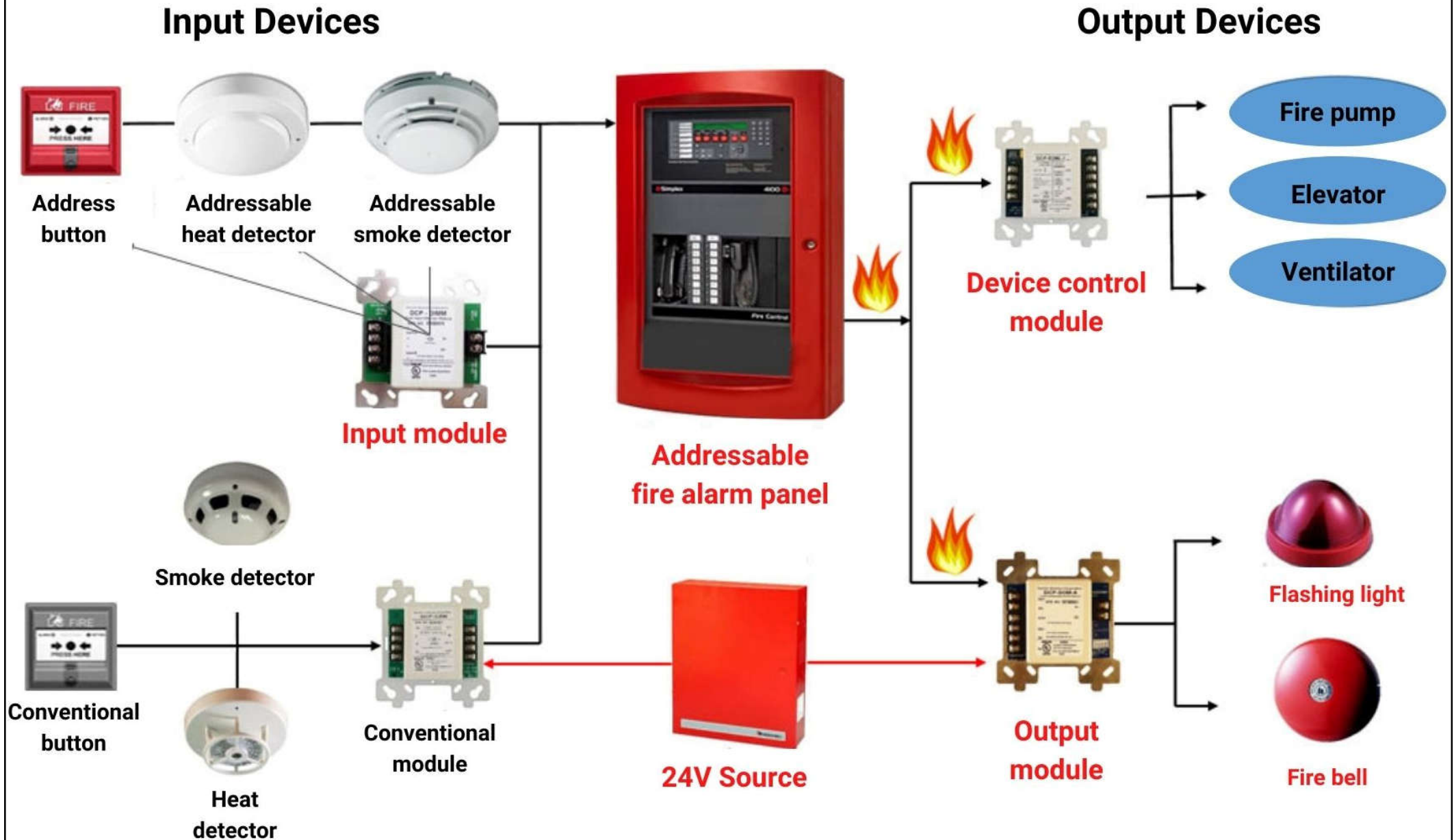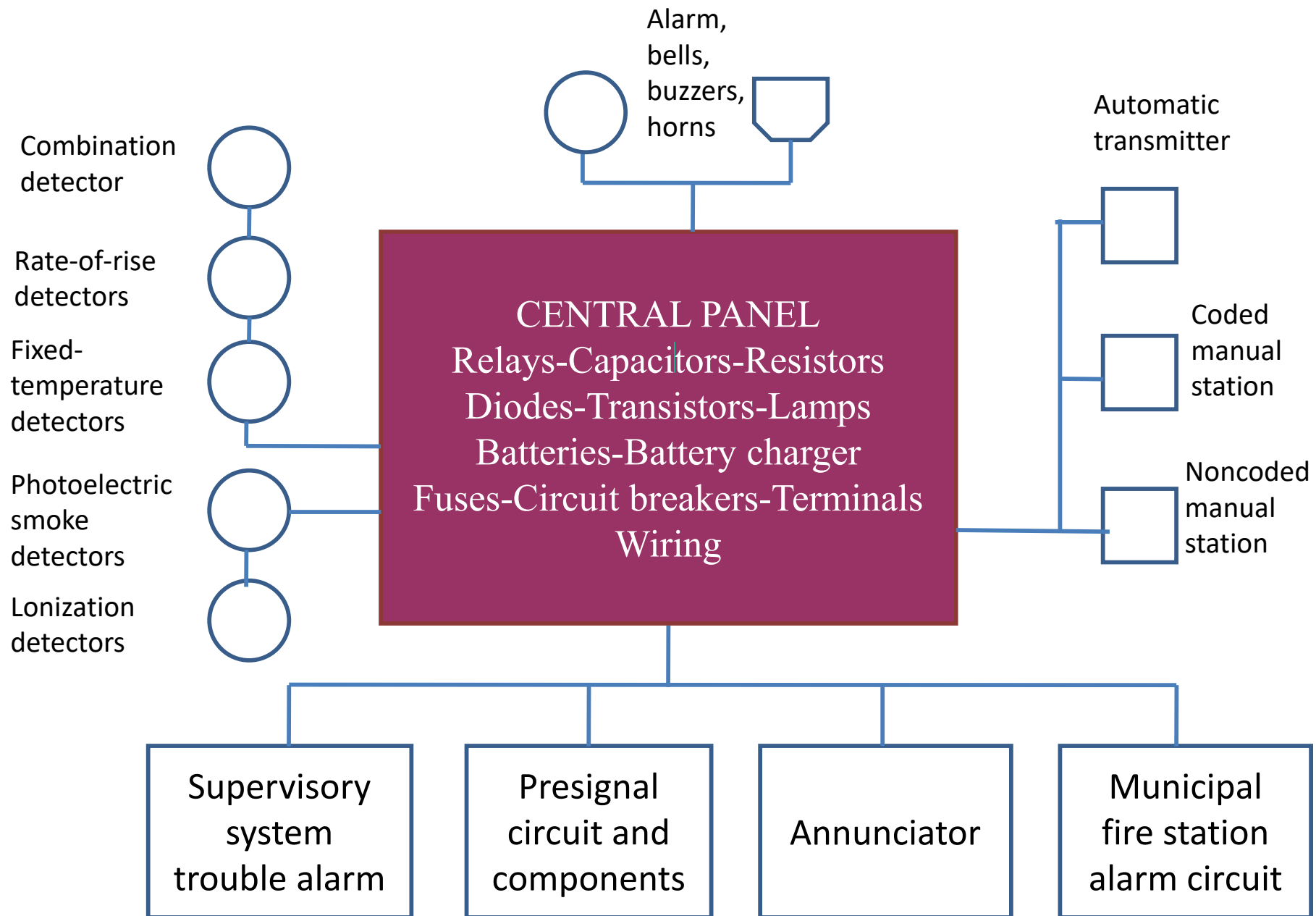- PMS/PGS
- Car Barriers System

Basic principles

- BAS can control all aspects of a building, including fire alarm & security systems

- <u>Traditional mind-set</u>: (fear of unknown risk)
  - BAS & fire alarm systems should maintain a significant level of separation with minimal connectivity or interaction

- <u>New thinking</u>: (advent of smart building)
  - Integration of BAS & fire alarm systems can result in overall efficiency in operation & reliability

Addressable fire alarm system

Input Devices

- Address button
- Addressable heat detector
- Addressable smoke detector
- Input module

- Smoke detector
- Conventional button
- Heat detector
- Conventional module

24V Source

Addressable fire alarm panel

Output Devices

Device control module
- Fire pump
- Elevator
- Ventilator

Output module
- Flashing light
- Fire bell

Components of a basic fire-alarm system

Alarm, bells, buzzers, horns

Combination detector

Rate-of-rise detectors

Fixed-temperature detectors

Photoelectric smoke detectors

Lonization detectors

CENTRAL PANEL
Relays-Capacitors-Resistors
Diodes-Transistors-Lamps
Batteries-Battery charger
Fuses-Circuit breakers-Terminals
Wiring

Automatic transmitter

Coded manual station

Noncoded manual station

| Supervisory system trouble alarm | Presignal circuit and components | Annunciator | Municipal fire station alarm circuit |

Schematic diagram of a fire-alarm main control panel

Legend:
- ◯ = Automatic smoke detector
- ▢ = Manual pull stations
- ◉ = Bell, buzzer, or horn annunciator

Station, Detector and Alarm Circuit

Alarm Circuit   Alarm Circuit

MAIN CONTROL PANEL

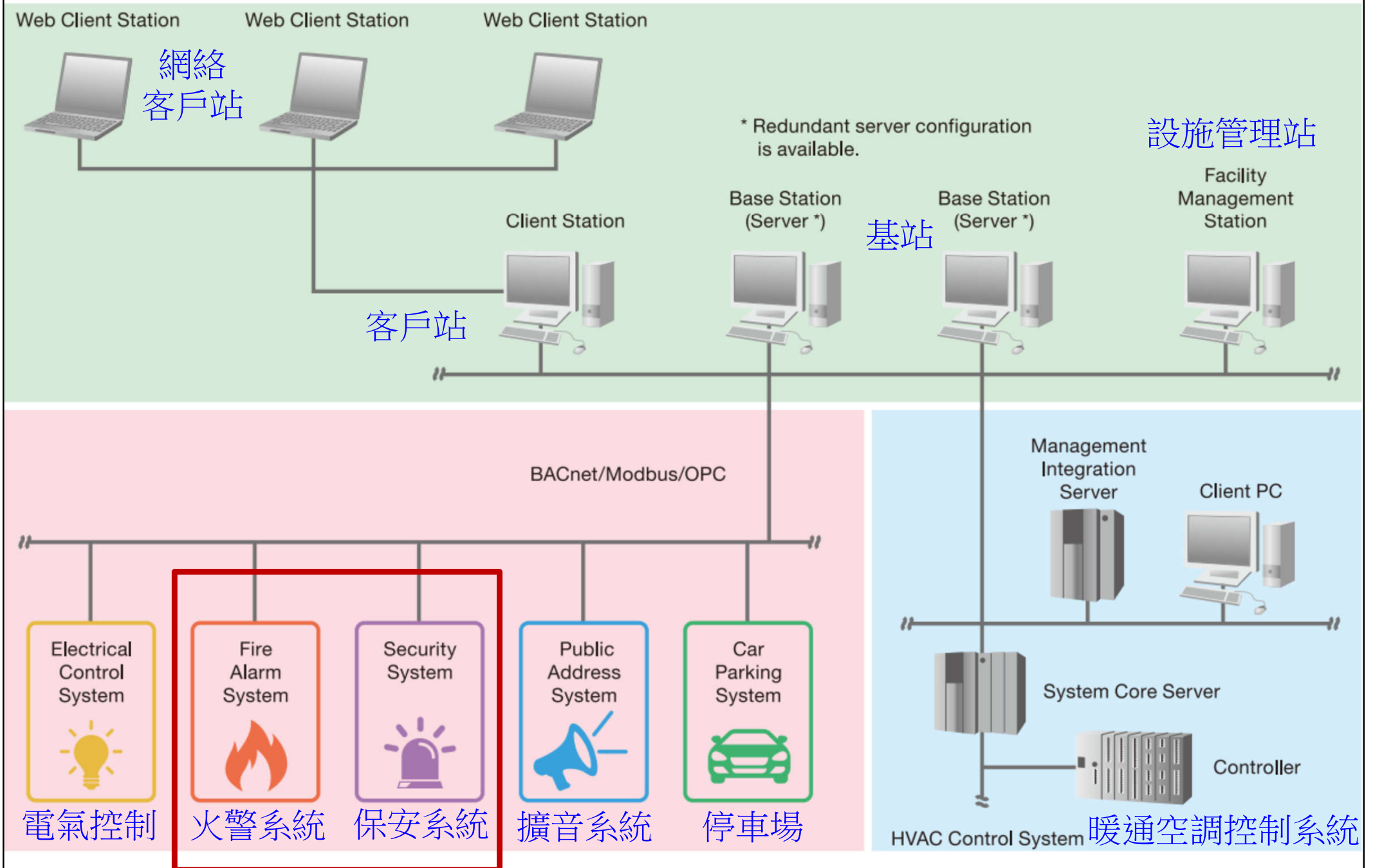Station and Detector Circuit

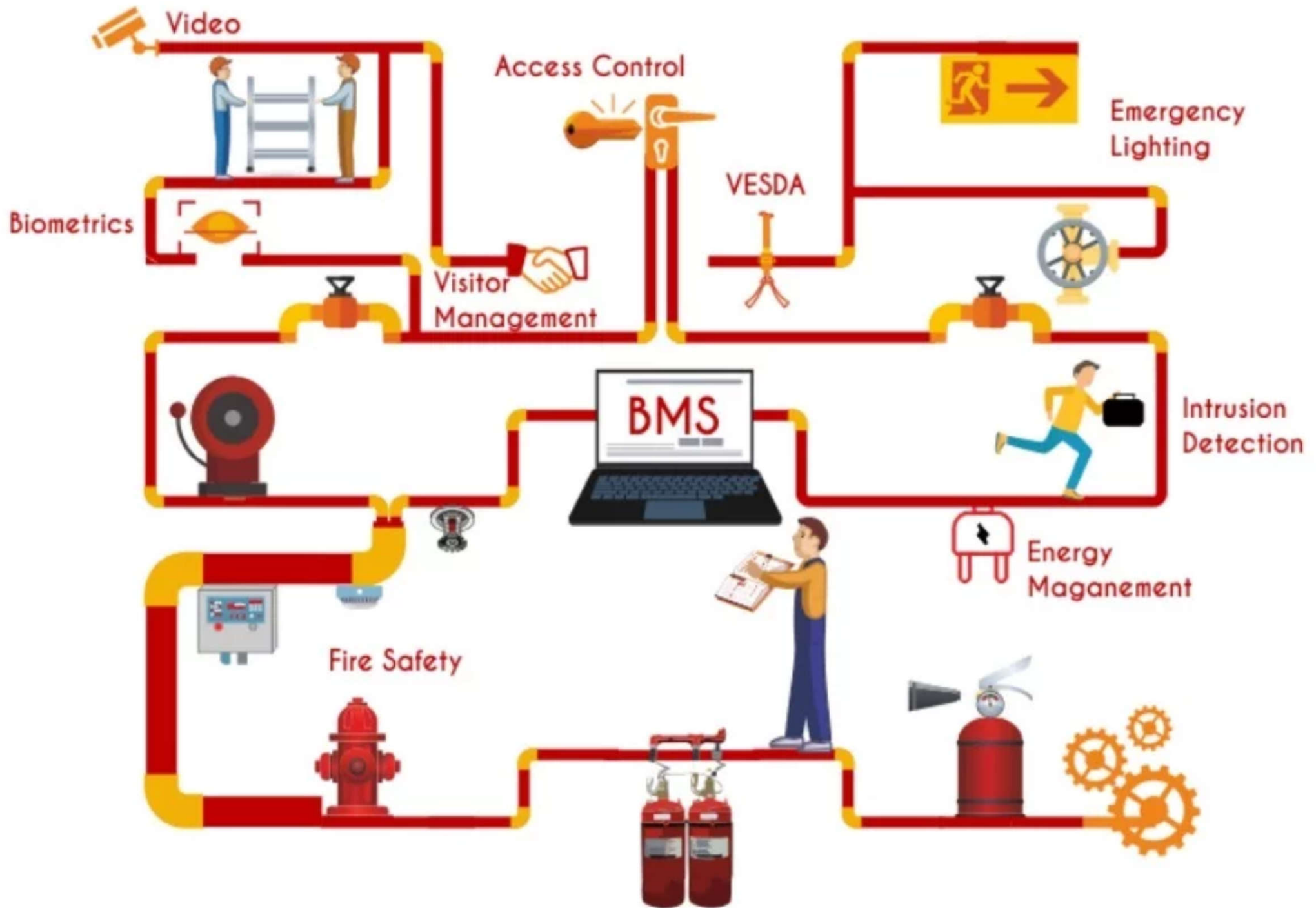120/240V AC

Supplementary Circuit
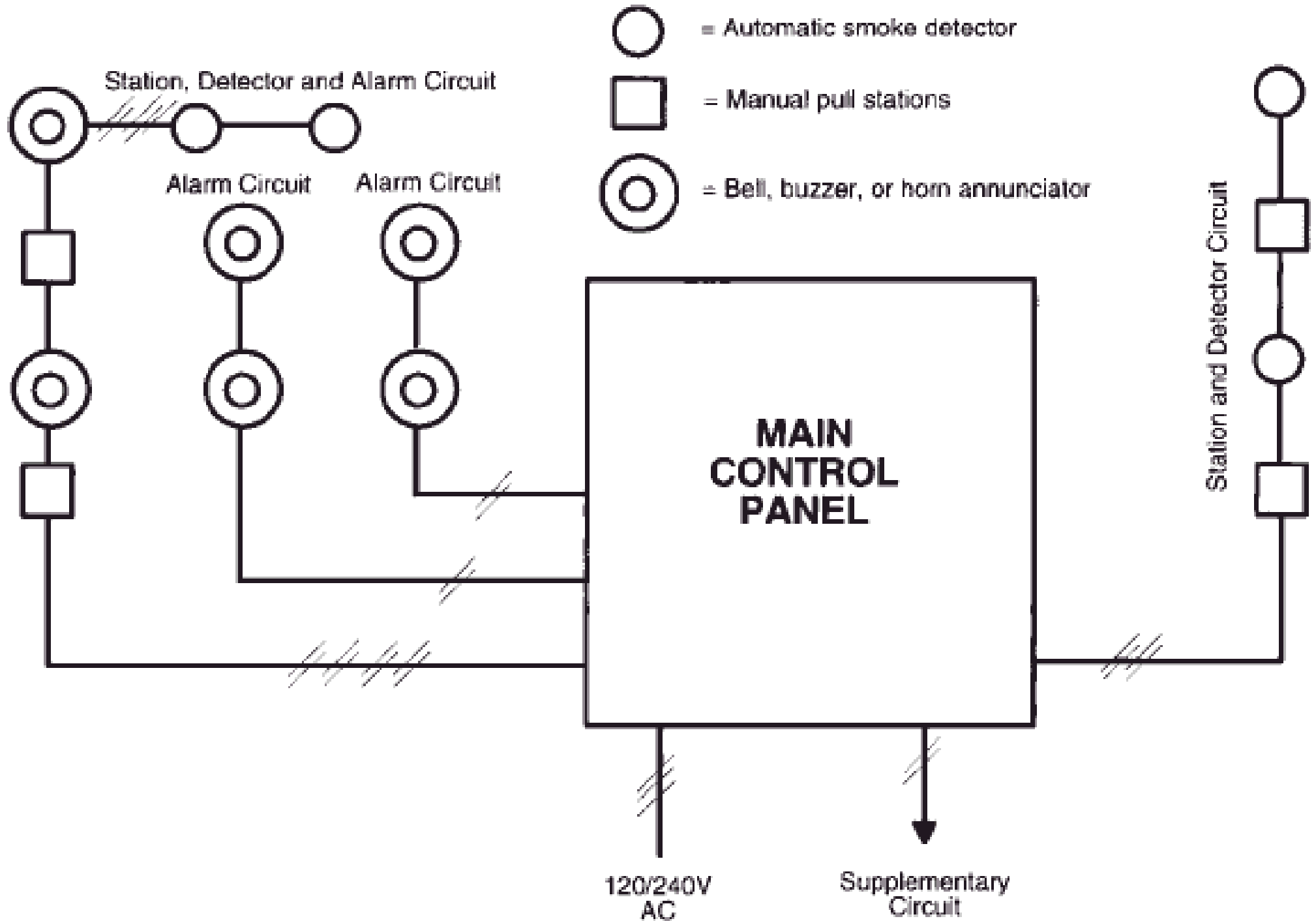
Basic principles

- BAS are sometimes linked to fire alarm systems, access control, other security systems & elevator/lift control for monitoring
  - In case a fire is detected then only the fire alarm panel could close dampers in the ventilation system to stop smoke spreading, shut down air handlers, start smoke evacuation fans, and send all the elevators to the ground floor & park them to prevent people from using them

Example of an integrated building management system

Web Client Station Web Client Station Web Client Station

網絡
客戶站

設施管理站

* Redundant server configuration
is available.

Client Station

Base Station
(Server *)

基站

Base Station
(Server *)

Facility
Management
Station

客戶站

BACnet/Modbus/OPC

Management
Integration
Server

Client PC

Electrical
Control
System

Fire
Alarm
System

Security
System

Public
Address
System

Car
Parking
System

System Core Server

Controller

HVAC Control System

電氣控制　火警系統　保安系統　擴音系統　停車場　　暖通空調控制系統

[Source: Azbil Corporation]

Integrated solution for fire safety, security & BAS/BMS

Basic principles

- BAS functionality in emergency situations
  - Power failures
    - A good BAS can review & restore the operation of fans, motors, pumps, chillers, and other points in sequence in order to prevent power surges
  - Fire/life safety
    - Alarms & voice commands
    - Smoke control & HVAC
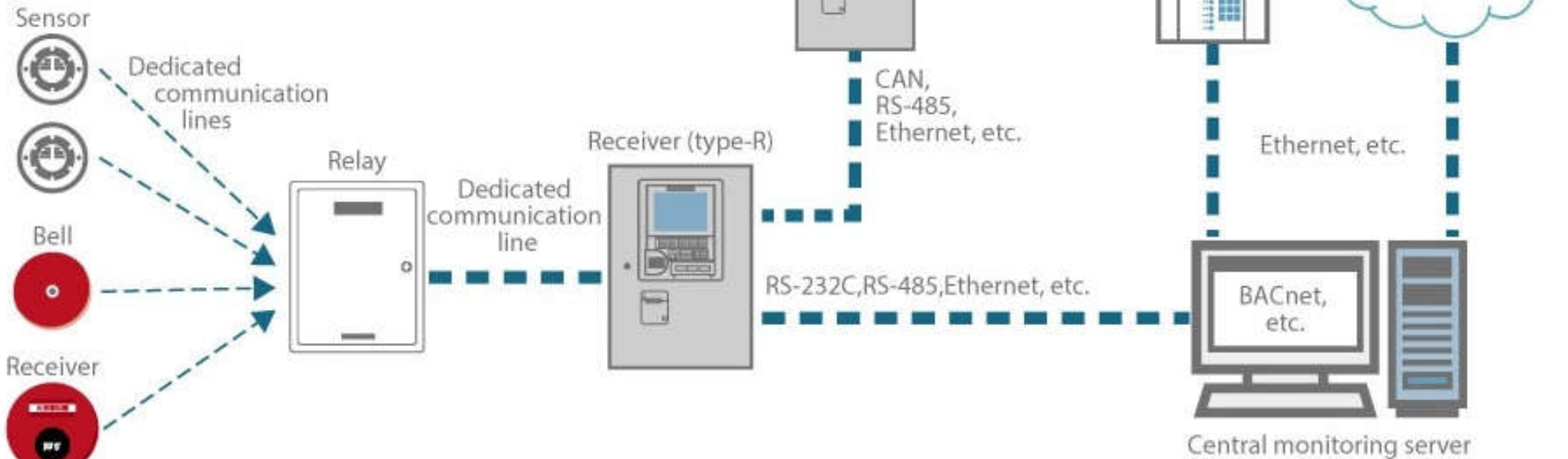   - Control of elevators/lifts
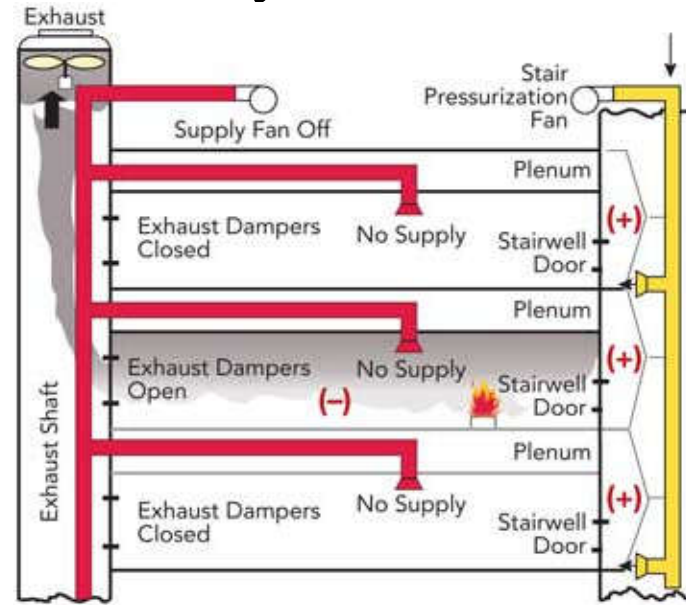   - Firefighter control & communication

(Source: https://www.fmlink.com/articles/building-automation-functionality-in-emergency-situations/)
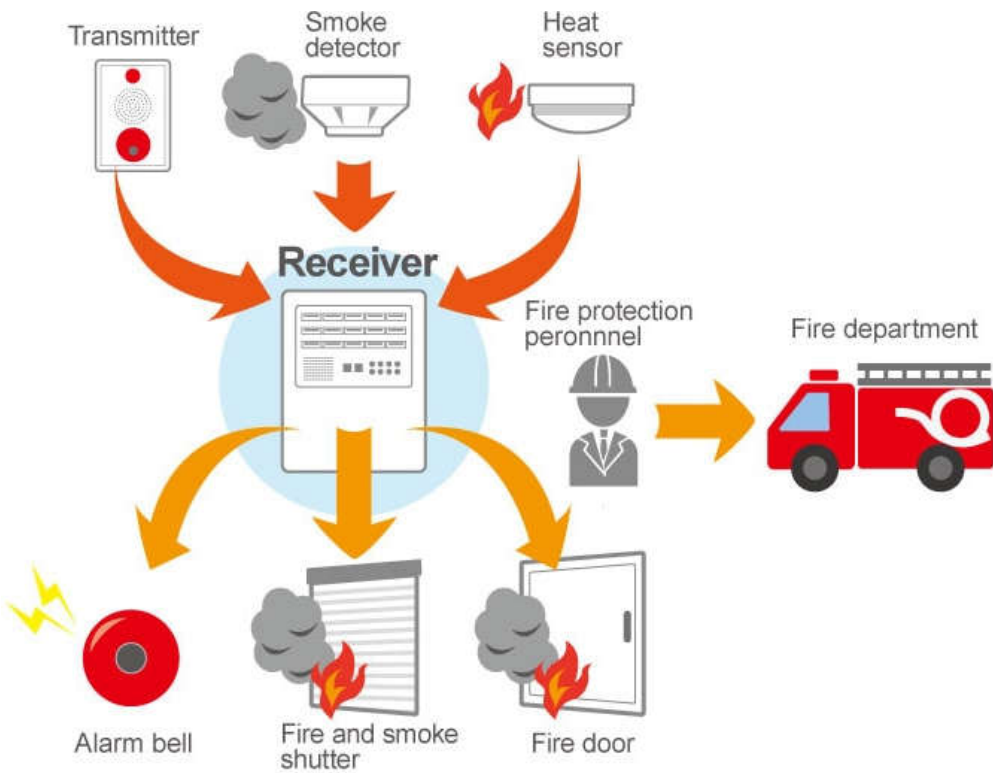
Basic principles

- BAS can provide real-time monitoring & alerts for fire & security issues, integrate with emergency response systems, etc.
  - For example, smoke control systems require the marriage of mechanical fan systems with fire protection/fire alarm systems
    - There is a certain level of priority and sequences that must be followed
    - If a smoke control fan operates before dampers open, ductwork may be damaged or door opening forces may be increased beyond acceptable levels for egress

Integration of BAS & fire alarm systems

(Source: https://www.renesas.com/us/en/application/industrial/building-home-automation/fire-safety-systems)
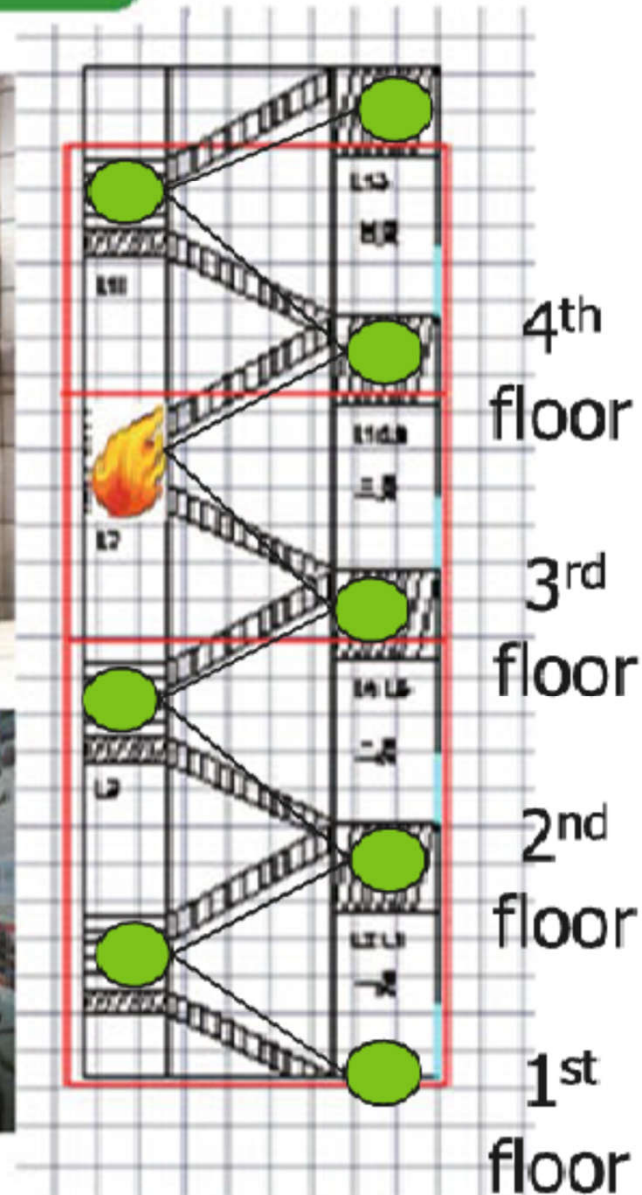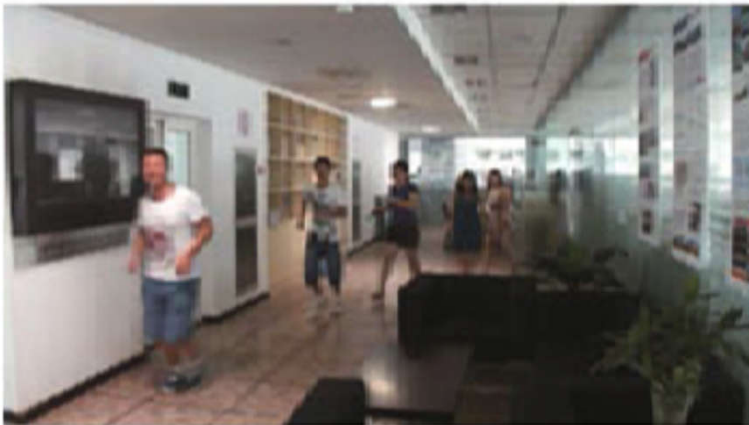
Basic principles

- BAS & fire alarm systems
  - Fire alarm products now often have a BAS gateway
    - Allows monitoring but little/no control
    - Manufacturers of both fire alarm & BAS can have bidirectional communication
    - Most fire alarm systems today have the capability to output fire alarm signals over BAS protocols
  - Use sensor data to estimate fire conditions
    - Non-fire signaling system
    - To ensure life safety is not impacted by any non-fire system, a listed barrier gateway must be provided to prevent other systems from interfering with or controlling the fire alarm system

Real-time evacuation guidance

(Source: Wen J. T. & Mishra S., 2018. *Intelligent Building Control Systems A Survey of Modern Building Control and Sensing Strategies*)
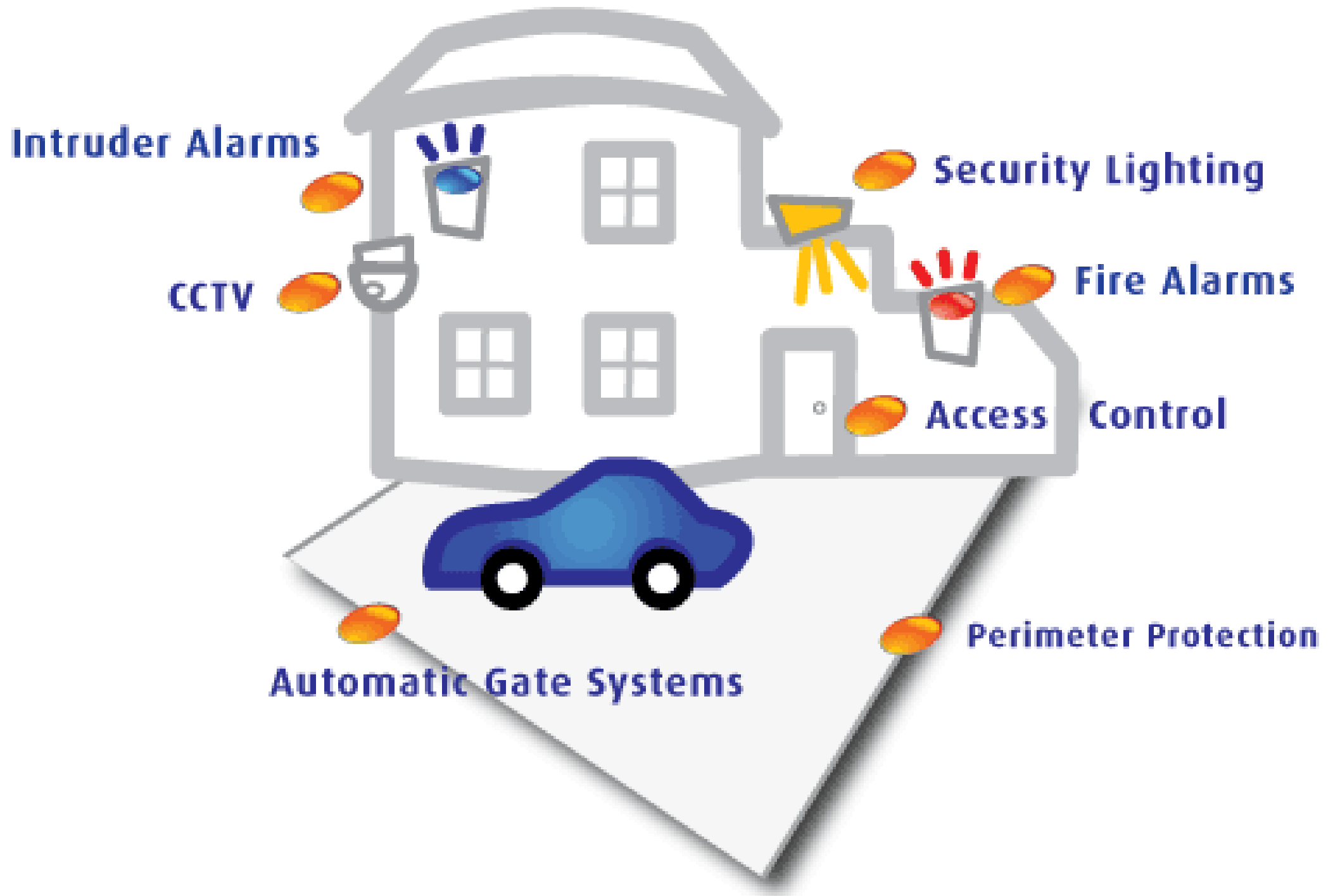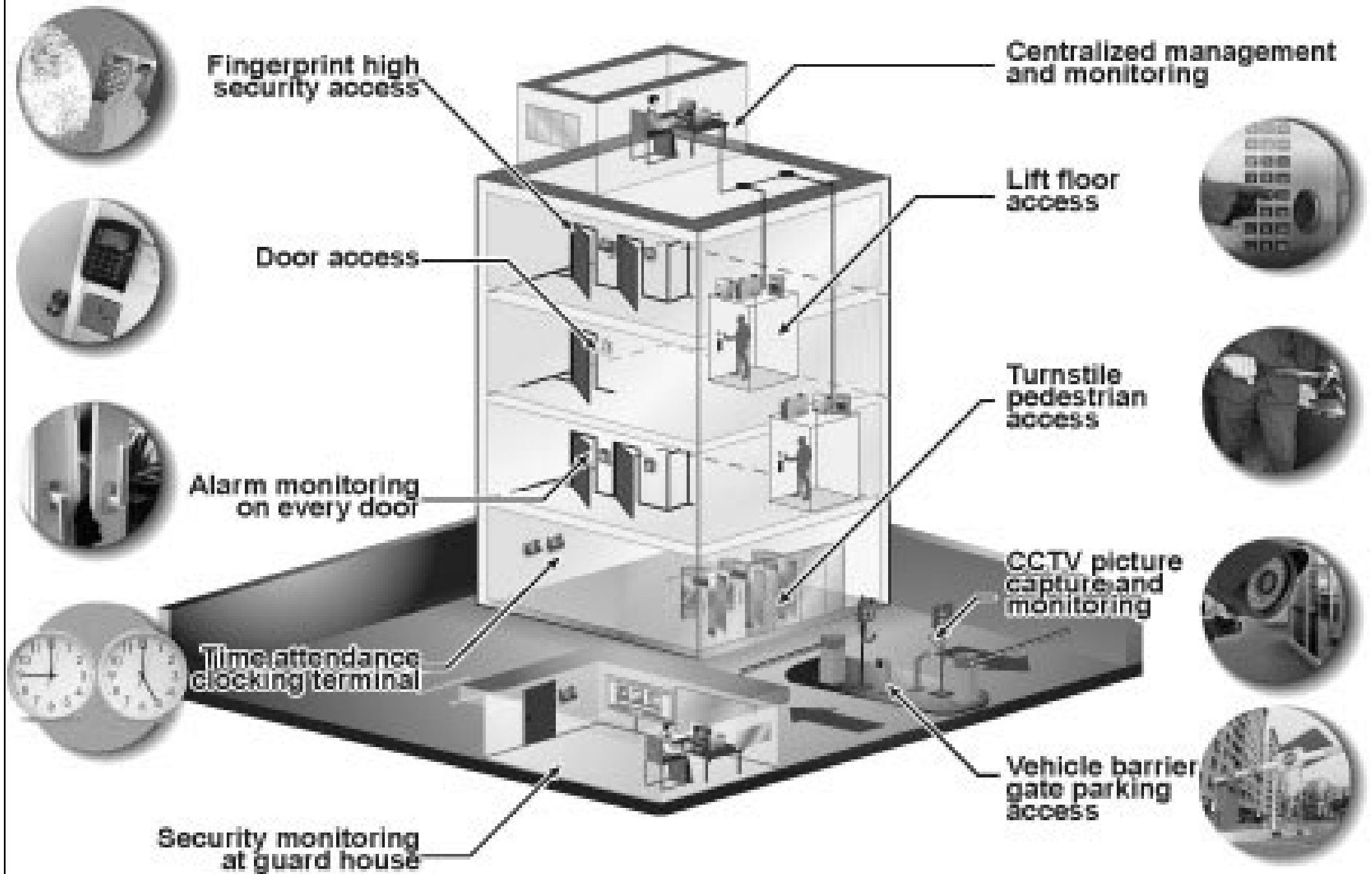
Security systems

- Security systems are indispensable to any type of building. They provide consistency in business operations and keep tangible assets, intellectual property & people safe

  - Each type of property is vulnerable to different hazards and requires a unique set of safety & security measures

  - Some common building security threats: unauthorized access, fire, accidents, or other situations that pose a hazard to human life

Common security & alarm systems

Intruder Alarms

CCTV

Security Lighting

Fire Alarms

Access Control

Automatic Gate Systems

Perimeter Protection

(Source: www.acesec.co.uk)

Security systems in commercial buildings

Fingerprint high security access

Door access

Alarm monitoring on every door

Time attendance clocking terminal

Security monitoring at guard house

Centralized management and monitoring

Lift floor access

Turnstile pedestrian access

CCTV picture capture and monitoring

Vehicle barrier gate parking access

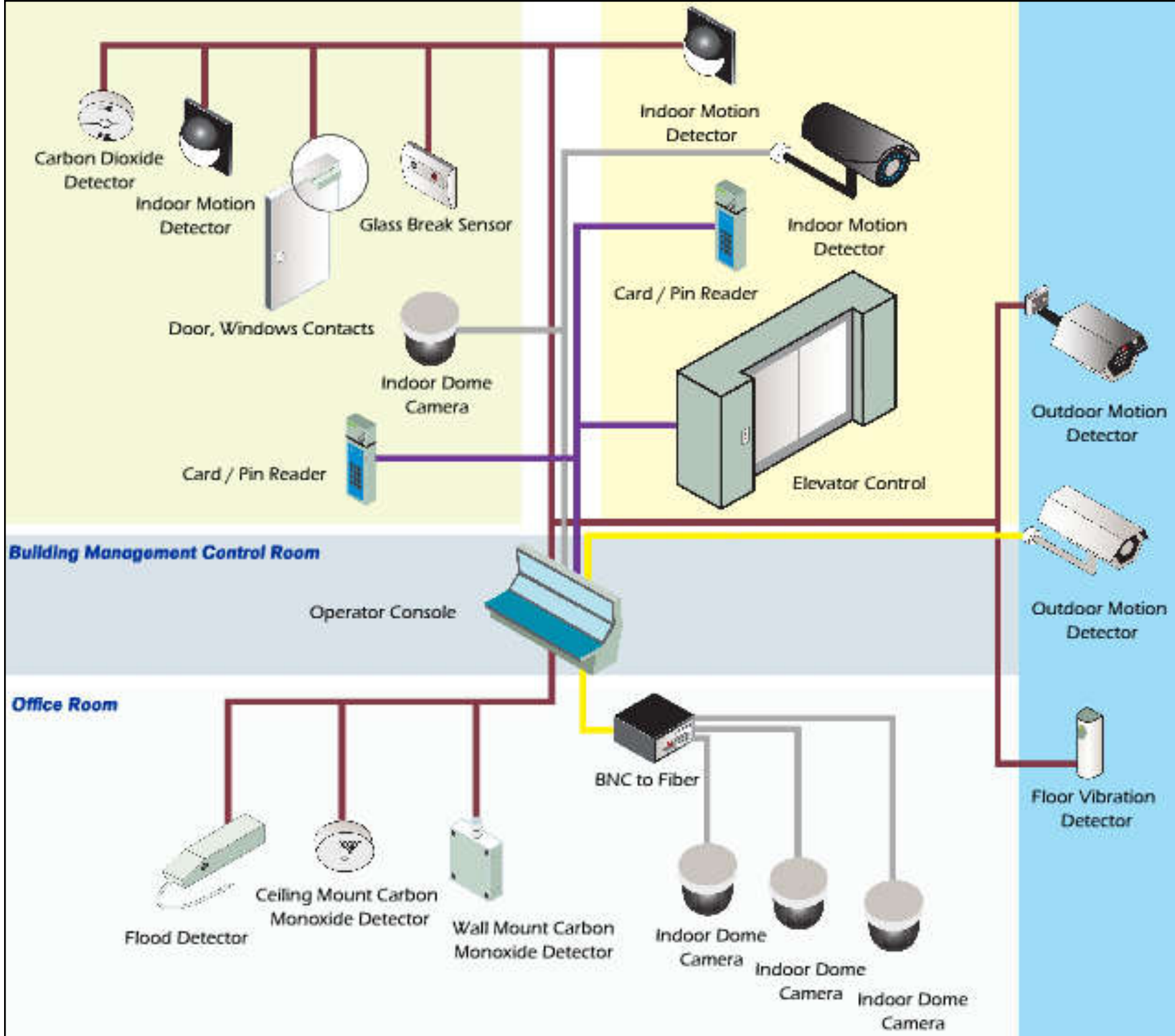(Source: https://centricstl.com/st-louis-building-automation-systems/)

Security systems

- Common types of security systems:
  - Burglar alarm system (central or local)
  - Closed circuit television (CCTV) surveillance
  - Intruder detection & access control
  - Intercom systems (audio/video)
  - Door-phone system & interlocking system
  - Panic attack (PA) button & sound system
  - Security lighting
  - Guard tour/monitoring system

Carbon Dioxide Detector

Indoor Motion Detector

Glass Break Sensor

Indoor Motion Detector

Indoor Motion Detector

Card / Pin Reader

Door, Windows Contacts

Indoor Dome Camera

Card / Pin Reader

Elevator Control

Outdoor Motion Detector

Outdoor Motion Detector

Building Management Control Room

Operator Console

Office Room

BNC to Fiber

Floor Vibration Detector

Flood Detector

Ceiling Mount Carbon Monoxide Detector

Wall Mount Carbon Monoxide Detector

Indoor Dome Camera

Indoor Dome Camera

Indoor Dome Camera

Examples of extra low voltage (ELV) security systems & devices in buildings

(Source: https://designsystemexamples.blogspot.com/2018/03/low-voltage-system-design.html)

Sensors & components of security & building management systems

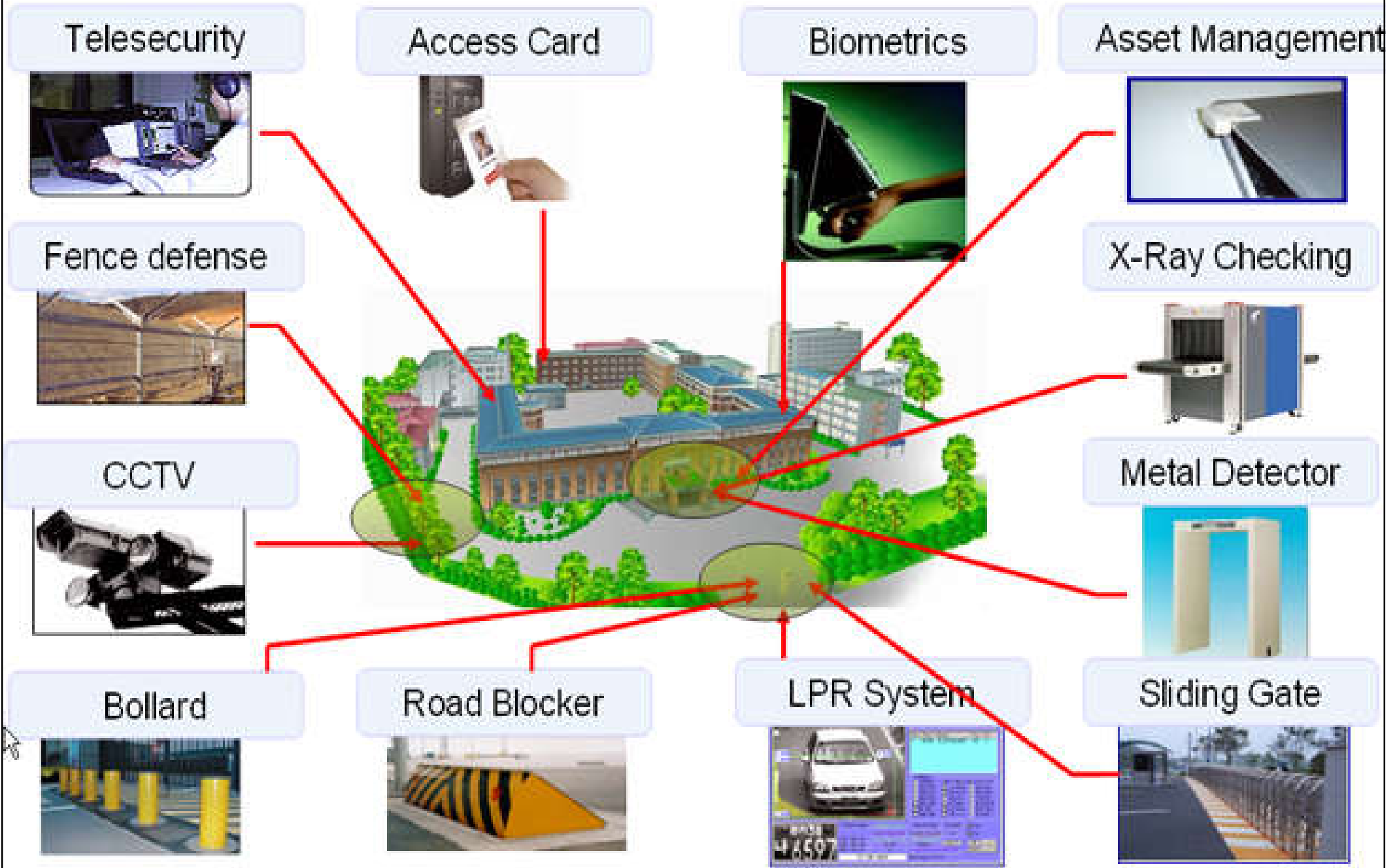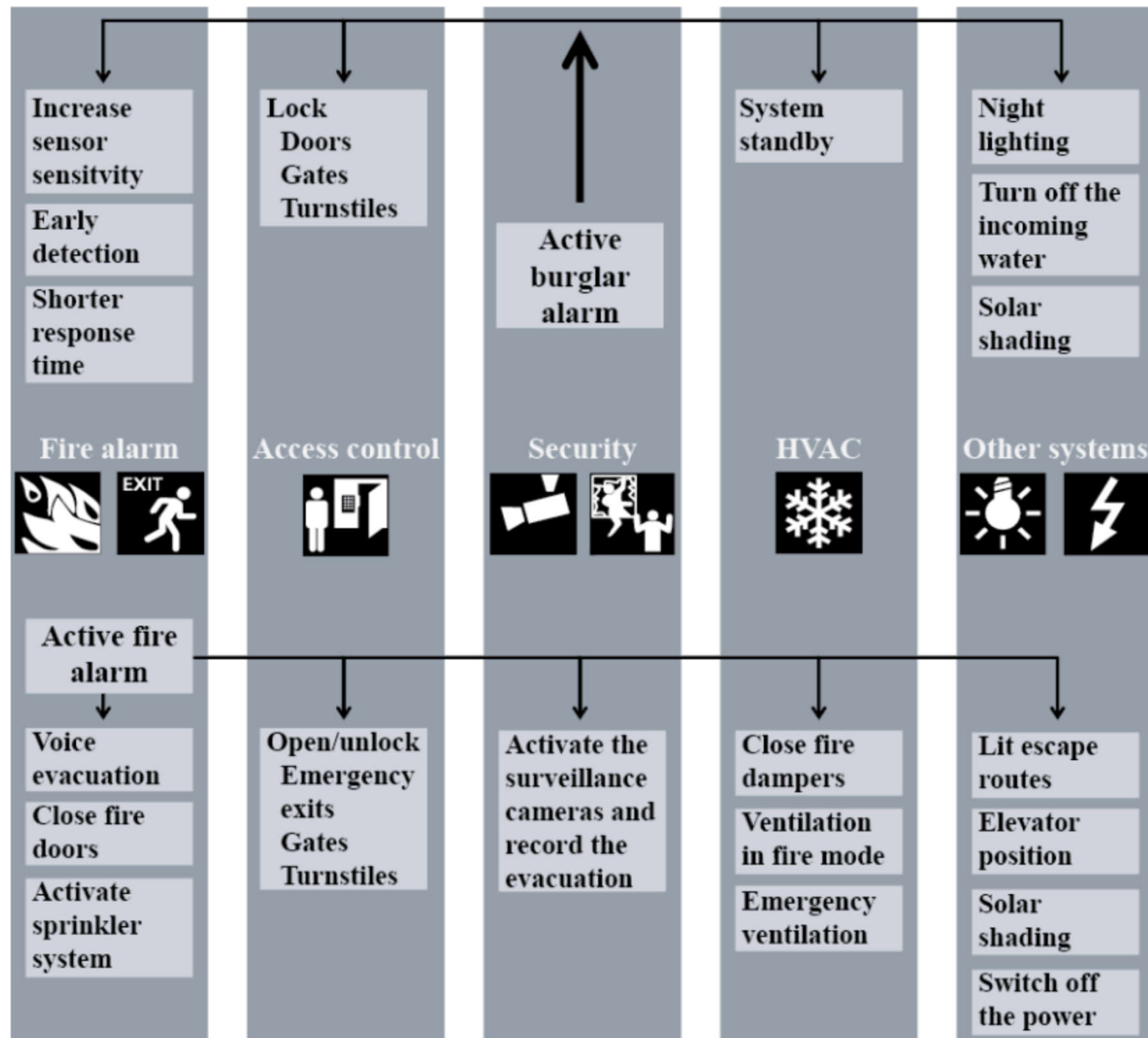# Crime prevention & monitoring functions of security systems

Crime prevention

- Glass break detectors
- Door open-close detectors
- Emergency notification
- Building ingress and egress management

Monitoring

- Motion detectors
- Smoke detectors
  High-temperature detectors
- Carbon monoxide detectors
- Surveillance cameras
- Room ingress and egress management

Typical components of security & alarm systems

Intrusion Alarms

Closed Circuit Television

Digital Video Surveillance

Access Control

Critical Process Monitoring

Security control room for a large building complex

Integrated security in a typical building management solution

Telesecurity

Access Card

Biometrics

Asset Management

Fence defense

X-Ray Checking

CCTV

Metal Detector

Bollard

Road Blocker

LPR System

Sliding Gate

Example of burglary & fire alarm with integrated functions in BAS

Fire alarm	Access control	Security	HVAC	Other systems
Increase sensor sensitvity	Lock Doors Gates Turnstiles	Active burglar alarm ↑	System standby	Night lighting
Early detection				Turn off the incoming water
Shorter response time				Solar shading

Fire alarm	Access control	Security	HVAC	Other systems
Active fire alarm				
Voice evacuation	Open/unlock Emergency exits Gates Turnstiles	Activate the surveillance cameras and record the evacuation	Close fire dampers	Lit escape routes
Close fire doors			Ventilation in fire mode	Elevator position
Activate sprinkler system			Emergency ventilation	Solar shading
				Switch off the power

(Source: Siemens Building Technologies, Inc.)

CCTV systems

- Closed circuit television (CCTV) system 閉路電視
  - Functions
    - 24 hour surveillance/deterrence
    - Real time or time lapse recording (on a closed loop basis)
    - Motion/alarm activated monitoring & recording
    - Area search using remotely controlled cameras
  - Integration with access control & other security systems
  - Components (now mainly digital)
    - Video camera (colour or monchrome)
    - Monitors, recorders and switchers
    - Multiplexer (triplex operation simultaneous playback & recording)
  - Key factors: quality, storage, export, playback

Different types of CCTV cameras

Types of cameras:-
• Dome camera
• Bullet camera
• Fisheye camera
• C-Mount camera
• Pan-tilt-zoom (PTZ) camera
• Day/Night camera
• Thermal camera
• Infrared/Night vision camera
• Network/IP camera
• Wireless camera
• High-definition HD camera

Basic concept of a multi-camera CCTV system

Monitor Unit

Lens   Camera   Hard Disk Recorder and multiplexer

Power

Coaxial Video Cables

Lens   Camera

Power

Power   Power

Lens   Camera

Power
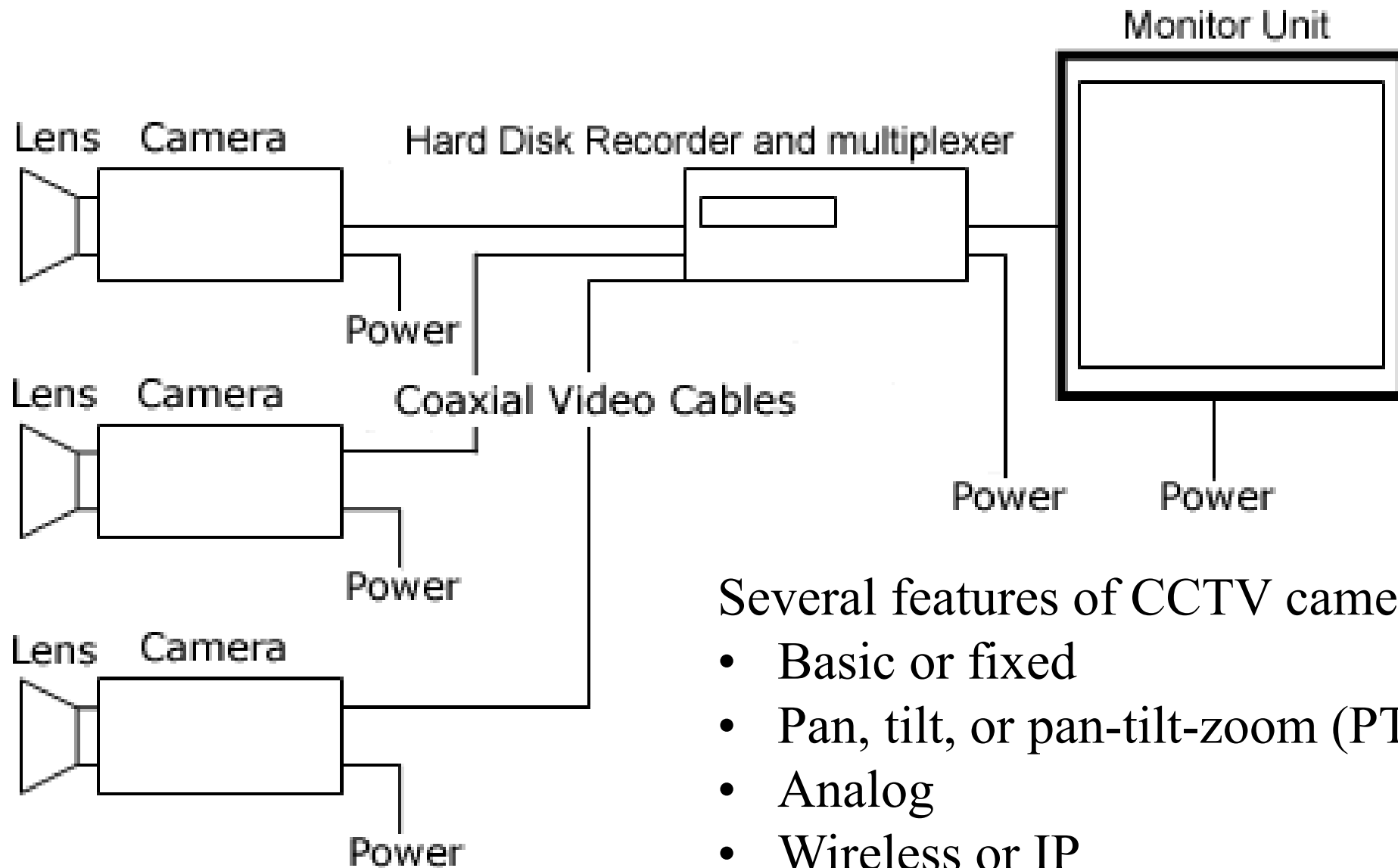
Several features of CCTV cameras:
- Basic or fixed
- Pan, tilt, or pan-tilt-zoom (PTZ)
- Analog
- Wireless or IP
- Night vision
- Exterior
- Motion-detection

CCTV systems

- Uses of CCTV systems:
  - Crime prevention (and deterring)
  - Crime investigation (a forensic tool)
  - Vehicle traffic monitoring (e.g. in car parks)
  - Pedestrian traffic (crowed) monitoring
  - Allow drivers to confirm people are clear of doors
  - Monitor access to secure or private areas
  - Employee/staff monitoring
  - Video surveillance in schools, shops or homes

The resolution makes a big difference – comparing CCTV cameras

5 Megapixel

2 Megapixel

1080P

700TVL - 960H WD1

CIF

(Source: https://kintronics.com/ip-cameras-better-analog-cctv-cameras/)

CCTV systems

- Technological advances of CCTV systems:
  - Video at full-colour & high-definition
  - Compression & storage of recordings
  - Save to the cloud via wired or Wifi network
  - Video content analysis (e.g. artificial intelligence)
    - Facial & image recognition, behaviours (suspicious or violent activities)
  - Internet protocol (IP) cameras
  - Wireless & networking security cameras
  - Talking CCTV (by the operator)

CCTV smart cameras for image recognition

Behavioral recognition by using CCTV video content analysis

| Violent Activity Recognition | Environment Safety | Traffic Monitoring |
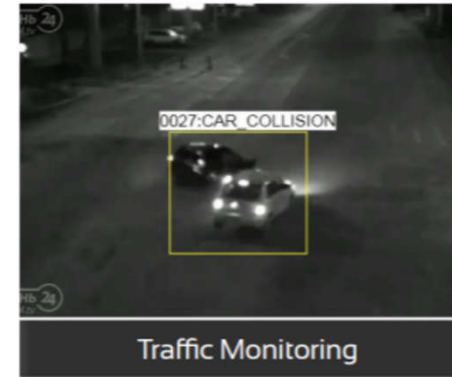
Violent Activity	**Suspicious Activity**	**Person & Crowd Behaviour**
• People fighting	• Contextual loitering, tailgating	• Crowd classification by size
• Brawl/Riot	• Person abandons an object	• Crowd moving /gathering /dispersing
• Vandalism	• Person with mask /no mask	• Occupancy analytics
• Person with blood	• Person running/walking/falling	• Person to person proximity
• Person with weapon	• Person gets in/out of a vehicle	
Perimeter Protection	**Traffic Monitoring**	**Environment+Personal Safety**
• Person entering/exiting predefined zone	• Vehicle counting & classification	• Smoke/Fire
• Vehicle entering/exiting predefine zone	• Vehicle behaviour	• Person with/without safety equipment
	• Accidents & hazards recognition	• Person/Equipment in hazard
	• Urban mobility (vehicle+person)	• Person falling/on the ground
	• Traffic congestion	

Video: Understanding for security and surveillance (3:04)
https://www.viisights.com/products/wise/

(Source: https://www.viisights.com/)

Internet-based CCTV systems

(Source: https://57543.8b.io/CCTVSystem.html)
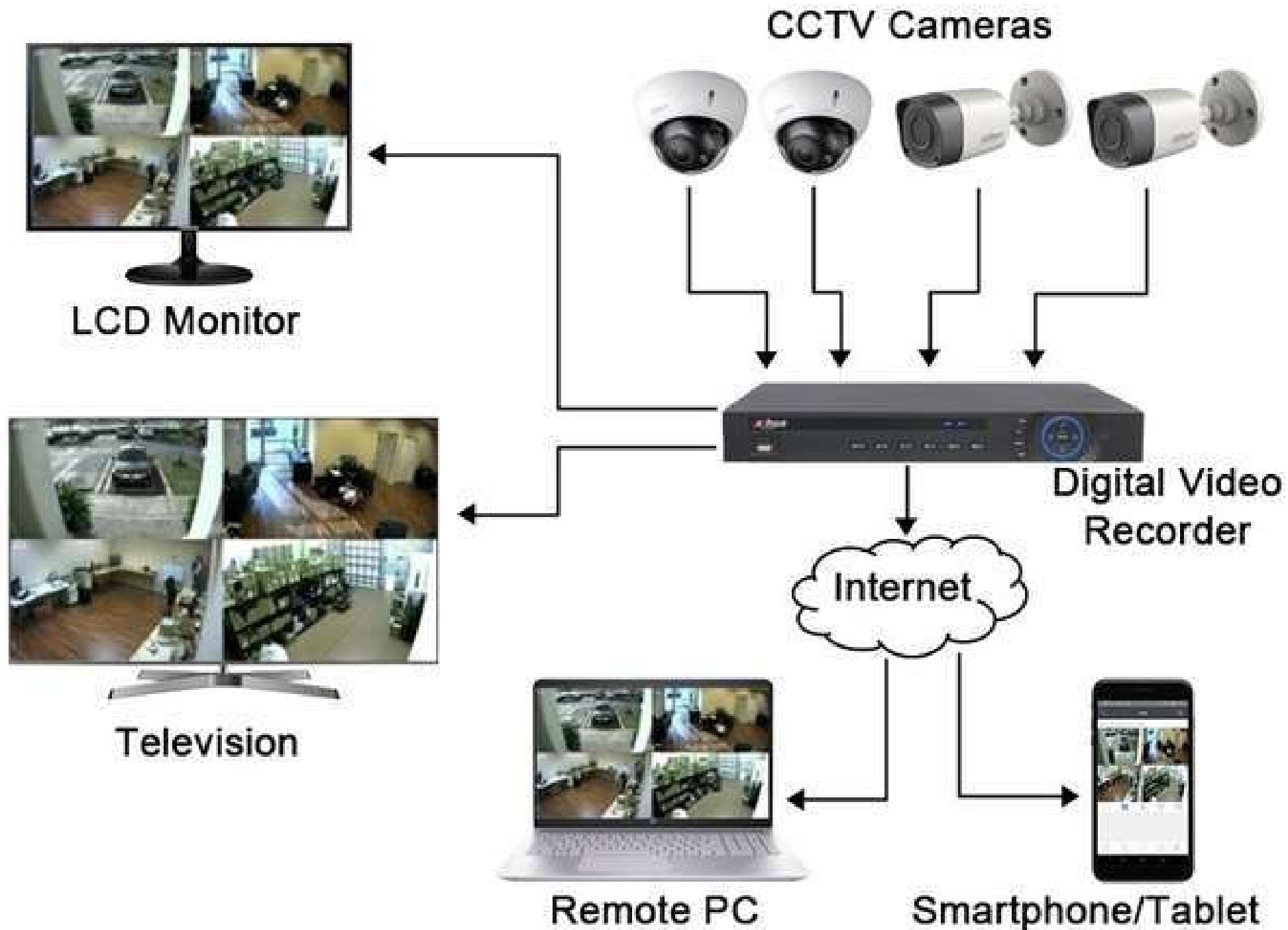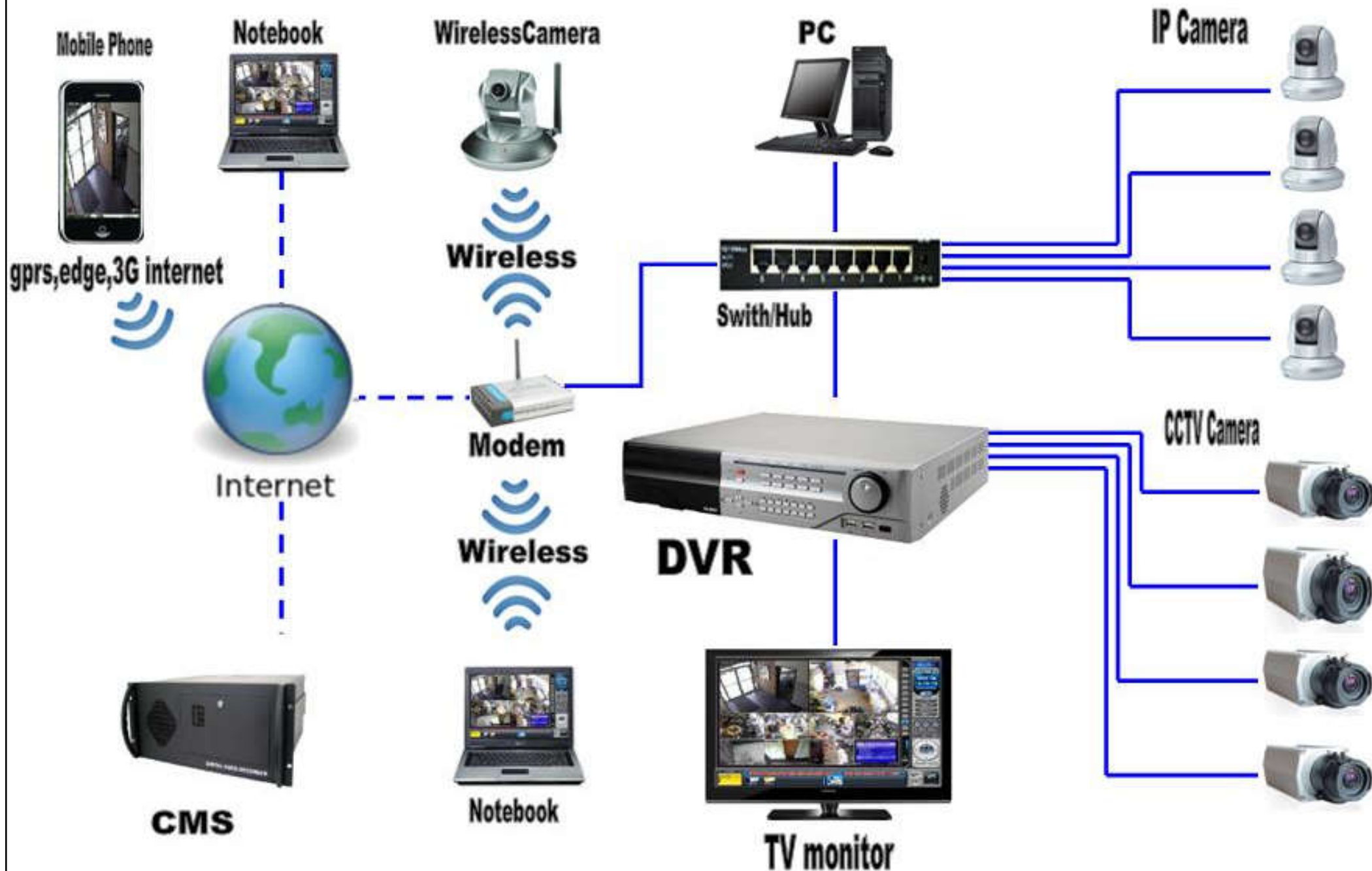
CCTV systems

- Internet protocol (IP) cameras
    - Connect to the network rather than to a digital video recorder (DVR) using a coax cable
    - The IP camera system includes not only the cameras but also the video recording system
    - Network infrastructure
    - Power over Ethernet (PoE): enough power to support IP devices
    - Video management & recording system
    - Network video recorders (NVR)

IP camera system diagram

Recording Servers

Client Display Stations

Network
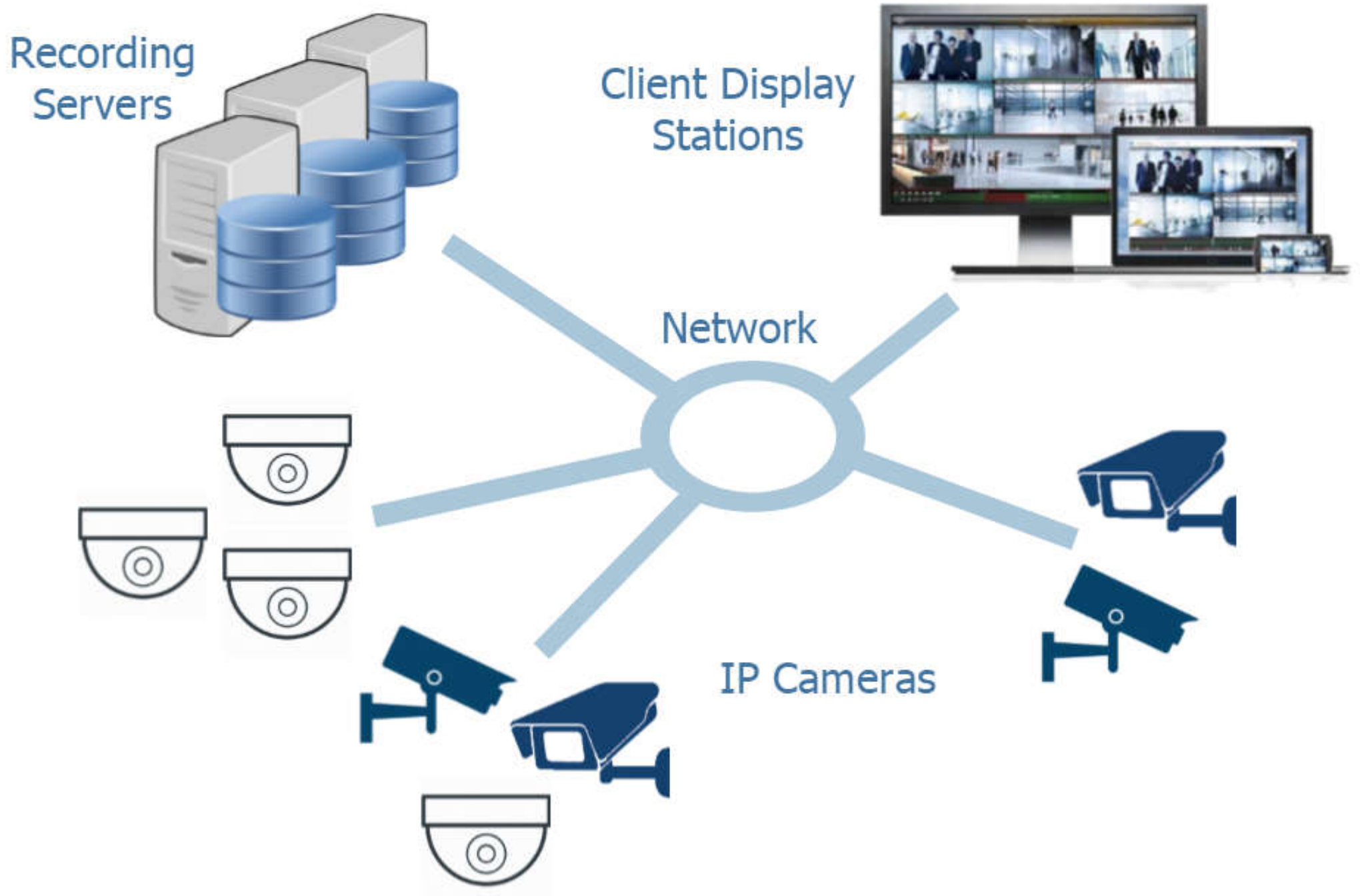
IP Cameras

Examples of CCTV installations with wireless, IP & analogue cameras

Mobile Phone

Notebook

WirelessCamera

PC

IP Camera

gprs,edge,3G internet

Wireless

Swith/Hub

Internet

Modem

Wireless

DVR

CCTV Camera

CMS

Notebook

TV monitor

Talking CCTV - the system's operator can challenge criminals or members of the public via an intercom system (help stop antisocial behaviour)

CCTV systems

- Security cameras as sensors for smart BAS
  - Use digital image processing & analytics to process & analyze data on-site, e.g.
    - Face recognition at entrances
    - Crowd management & counting the number of people
    - Object tracking to prevent theft & vandalism
    - Recognition of vehicle license plates
    - Perimeter detection to help trigger alarms when unauthorised individuals try to gain access into the building & surrounding environment
    - Object detection & identification

Features of CCTV camera to support smart building automation

- HD Video Quality
  - 1080P
- Field Of View
  - 360°
- Motion Detection
- Two-way Audio
- Night Vision Mode
- Cloud or Local Storage

CCTV systems

- Integrate CCTV with smart cameras into BAS
  - Provides the opportunity to react to critical events (security, safety or water ingress)
  - Provide relevant video data & most important concurrently initiating appropriate actions (e.g., smoke extraction in case of fire)
  - Detect the presence of people which act as additional input parameter for the HVAC control (sensor fusion & sharing)
  - Video analytics & intelligence

BACnet-based camera structure & smart video surveillance

(Source: Zhou N., Zhou M.-L. & Xu Y.-P., 2004. BACnet® for video surveillance, *ASHRAE Journal*, 46 (10) S18-S23.)
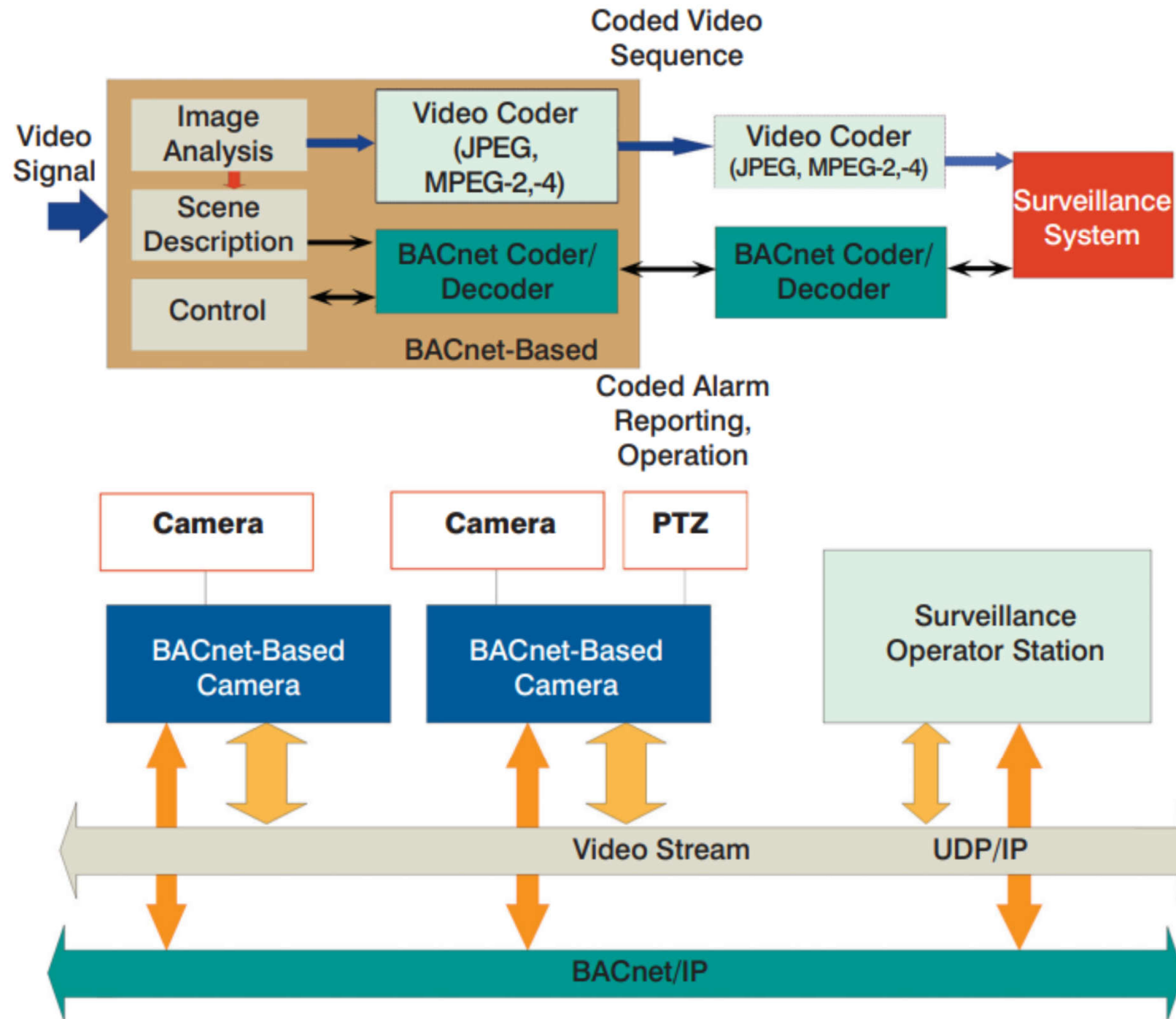
CCTV systems

- BACnet-based camera integrated with BAS
  - 1. <u>Image analysis</u>
    - Extract the content-based description at the camera
  - 2. <u>Scene description</u>
    - Allows more flexibility in the design of complex & powerful surveillance + greater interoperability
  - 3. <u>Control</u>
    - Pan, tilt, zoom (PTZ), focus, automatic scanning, etc.
  - 4. <u>BACnet coder/decoder (CODEC)</u>
    - Video coder is required to transmit digital video data

Access control systems

- Access control
  - Stand-alone or online systems
  - Methods:
    - Digital codes
    - Magnetic stripe cards
    - Embedded wire cards
    - Proximity cards/tags
    - Biometric access control (e.g. retina, finger prints)
  - Pedestrian turnstiles (like in subway stations)
  - Car park control (e.g. car park ticket validation)

Integrated Photo ID Badge and Access Control System
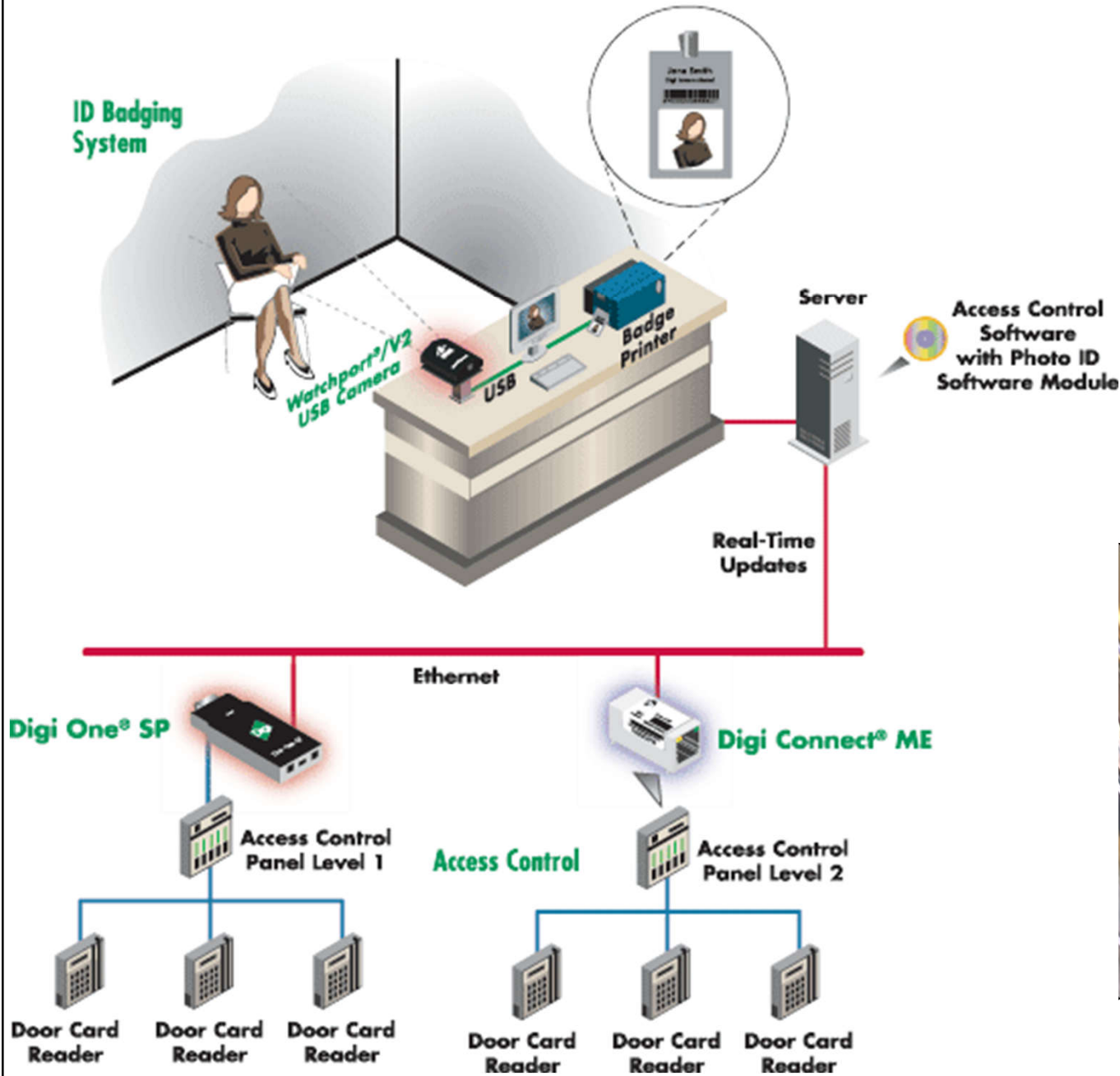
Access control system

ID Badging System

Jane Smith

Watchport®/V2 USB Camera

USB

Badge Printer

Server

Access Control Software with Photo ID Software Module

Real-Time Updates

Ethernet

Digi One® SP

Digi Connect® ME

Access Control Panel Level 1

Access Control

Access Control Panel Level 2

Door Card Reader   Door Card Reader   Door Card Reader

Door Card Reader   Door Card Reader   Door Card Reader

Pedestrian turnstiles

Car park control system

(Source: http://www.baps.co.nz)
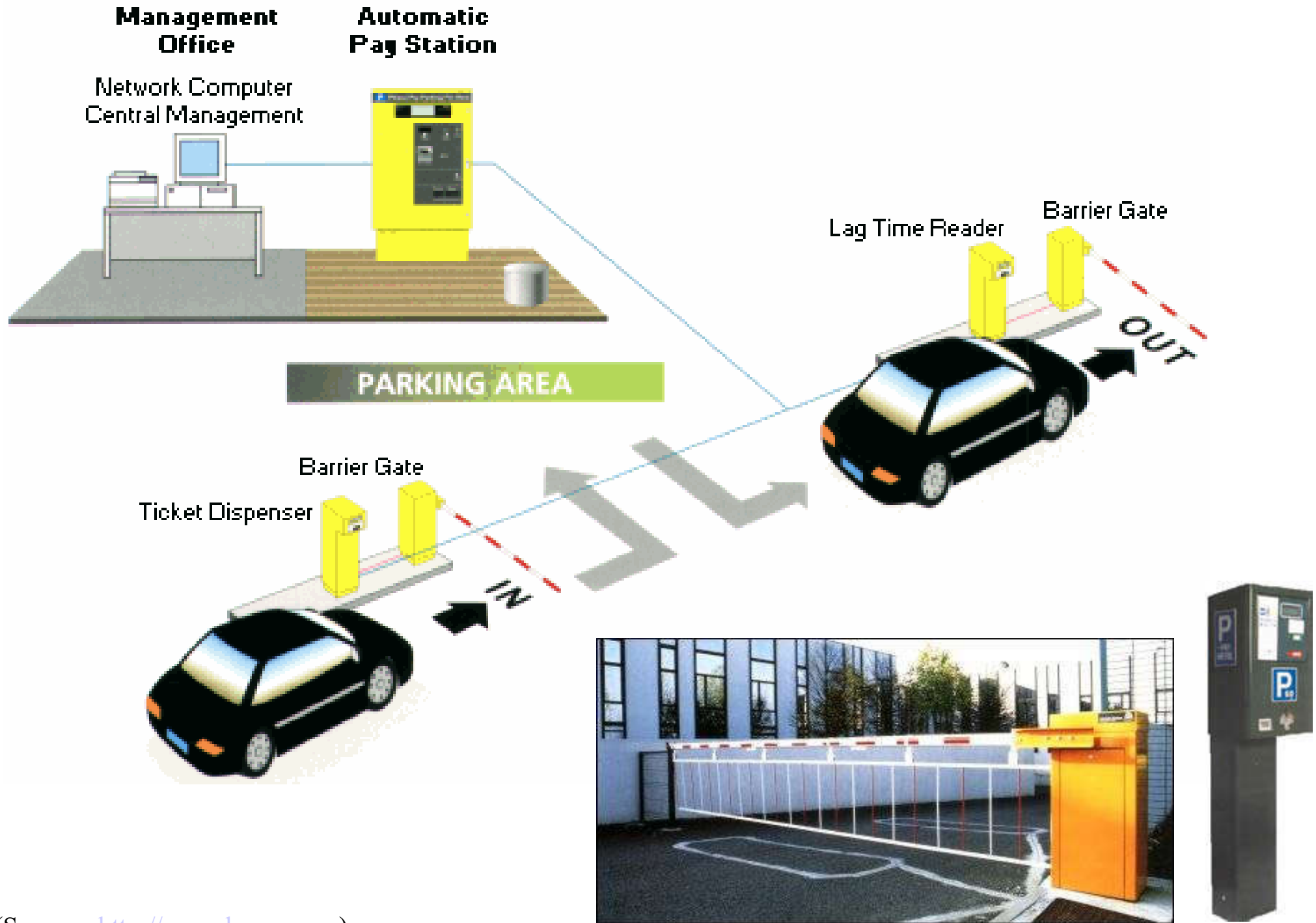
Access control systems

- Access control system (ACS)

  - Control passage into or out of any area

  - Computer-based, electronic access control

  - Basic components:

    - Access cards & card readers

    - Access control keypads

    - Electric lock hardware

    - Access control field panels

    - Access control server computer

  - Latest trend: wireless & cloud-based systems

Examples of door access control systems (with door control readers, metal detectors, intercoms, IP cameras & emergency paging system)

Door Control Systems
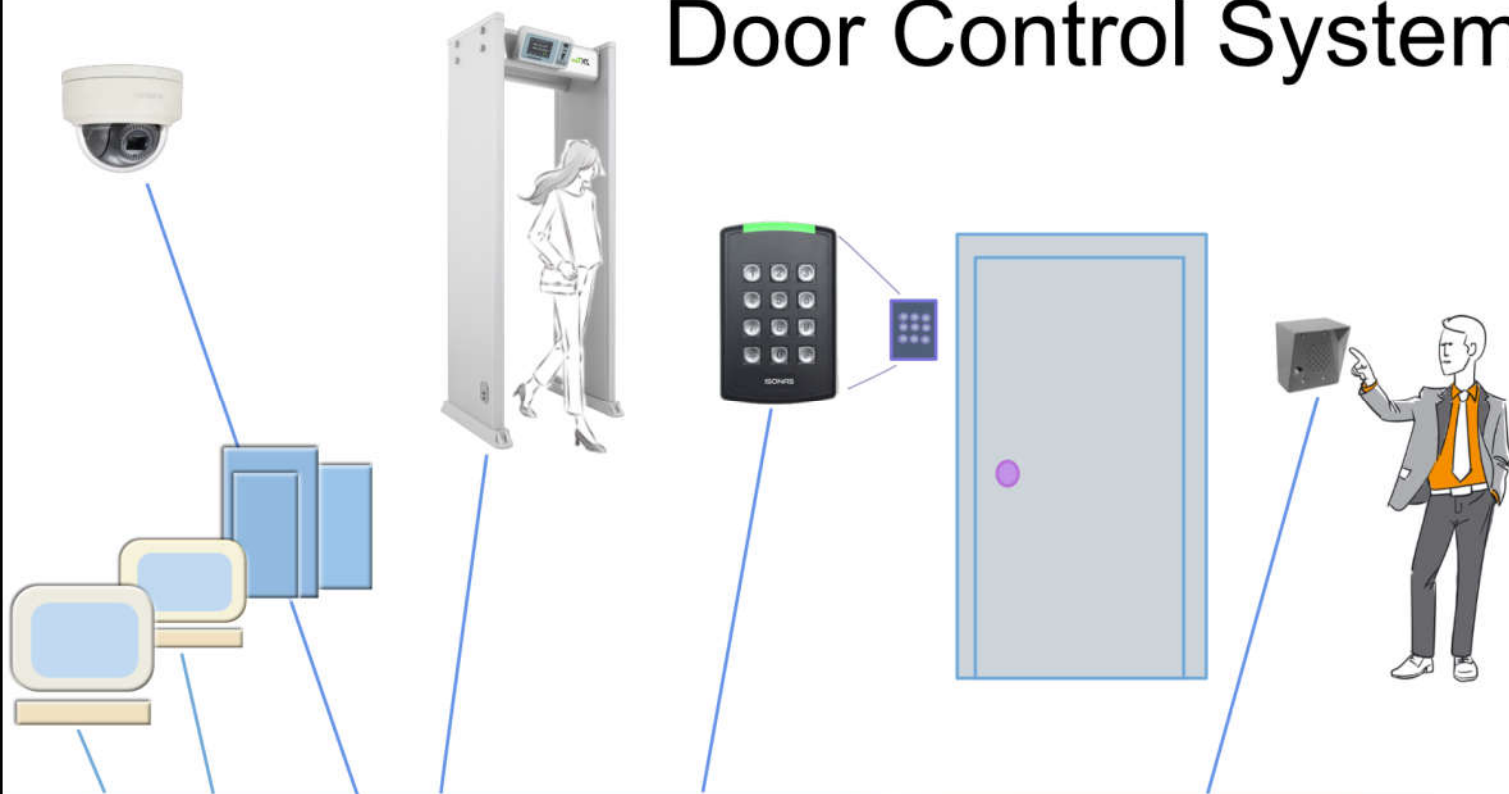
What are the key factors for door access control?

Various levels of security for door access control systems

Level 1 Security – PIN Numbers	Lock with keypad Door Reader with keypad
Level 2 Security – Credentials	RFID IP Reader Intelligent IP Reader
Level 2.5 Credentials With Video	
Level 3 Security – Dual Authentication Systems	RFID IP Reader Intelligent IP Reader with Keypad
Level 3.5 Dual Authentication Plus Video	
Level 4 Security – Biometric Readers	Biometric IP Reader
Level 4.5 Biometric Readers Plus Video	

PIN = Personal identification numbers
RFID = Radio frequency identification
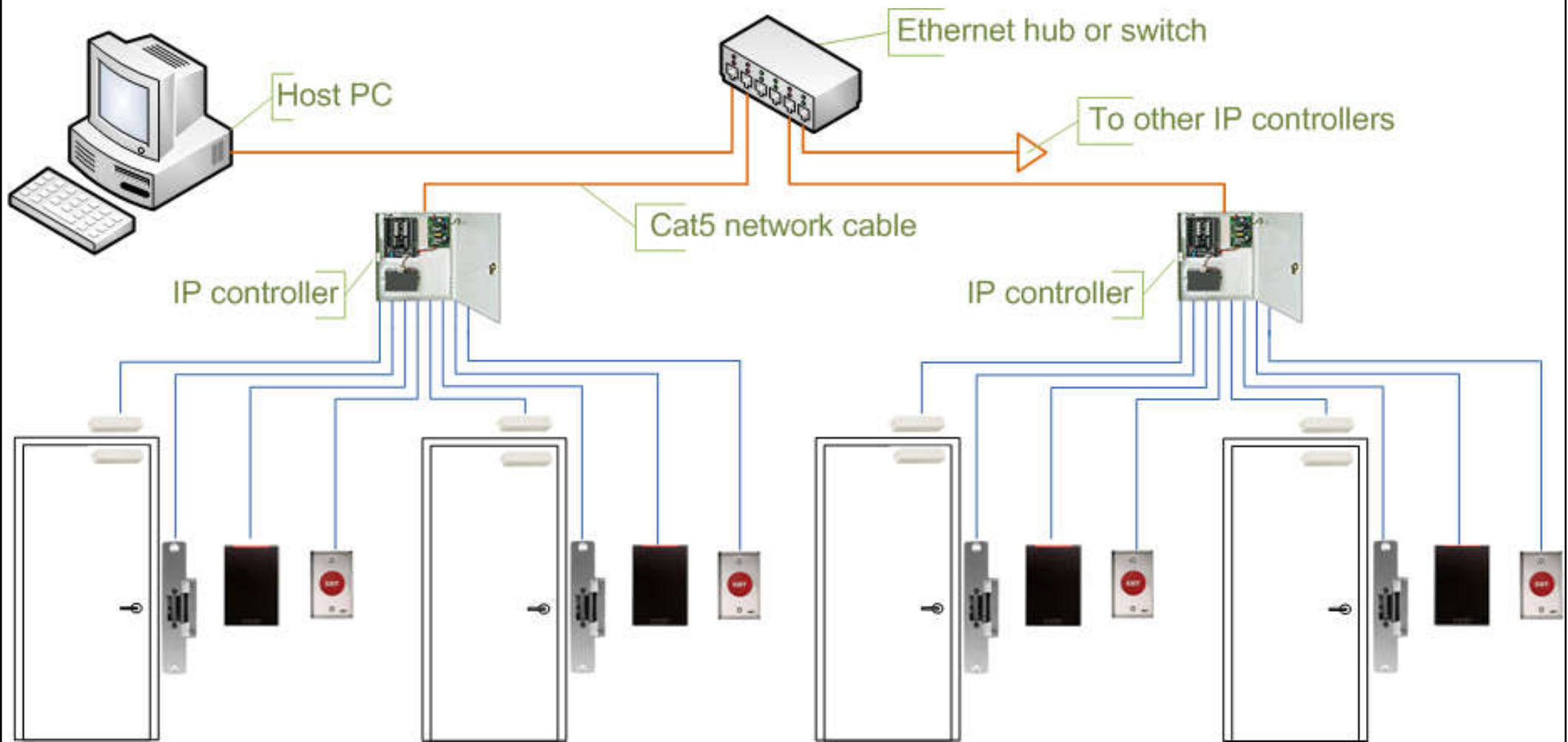IP = Internet protocol
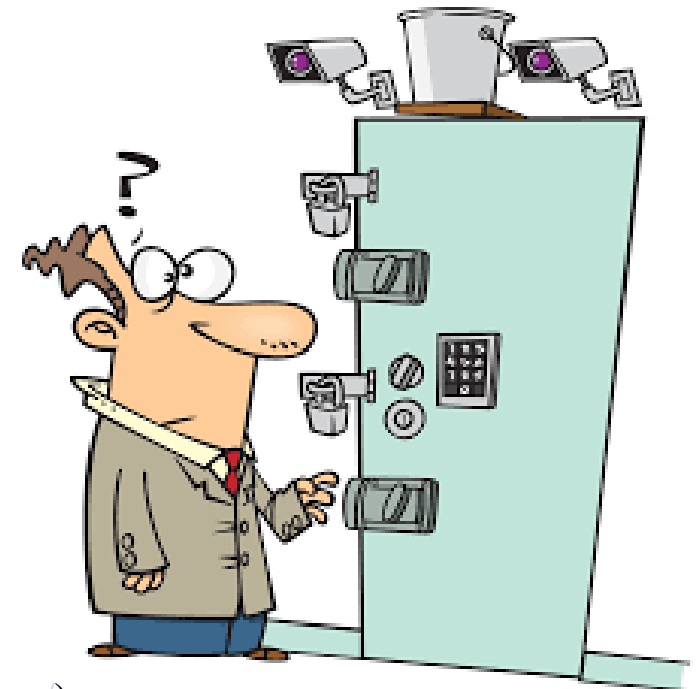
Typical access control door wiring

Door contact

To Control Panel

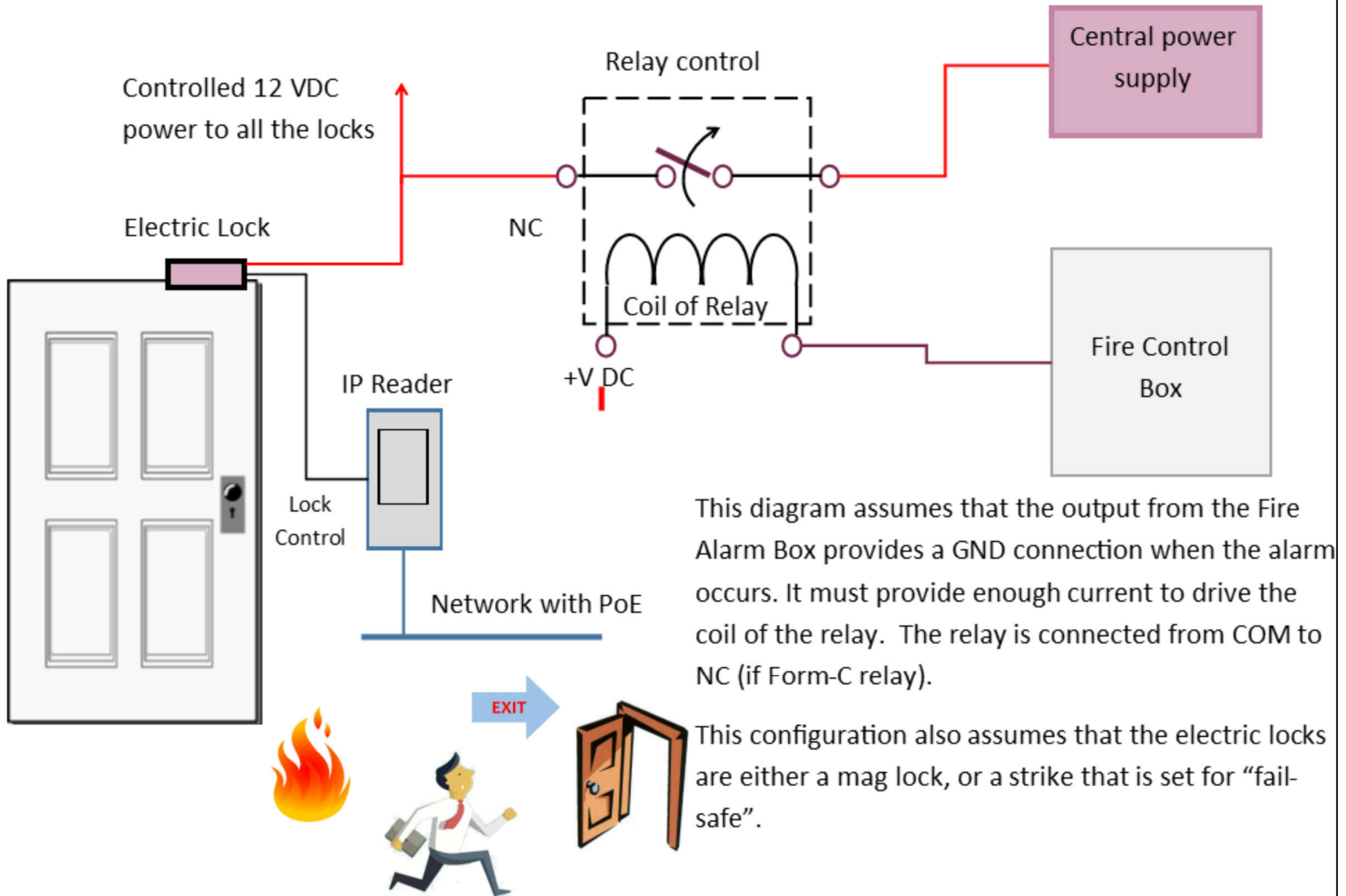To host PC or main control panel

Door contact

Exit button

Reader (card, keypad or biometric)

Electric strike

Exit button

Intelligent Reader (card, keypad or biometric)

Electric strike
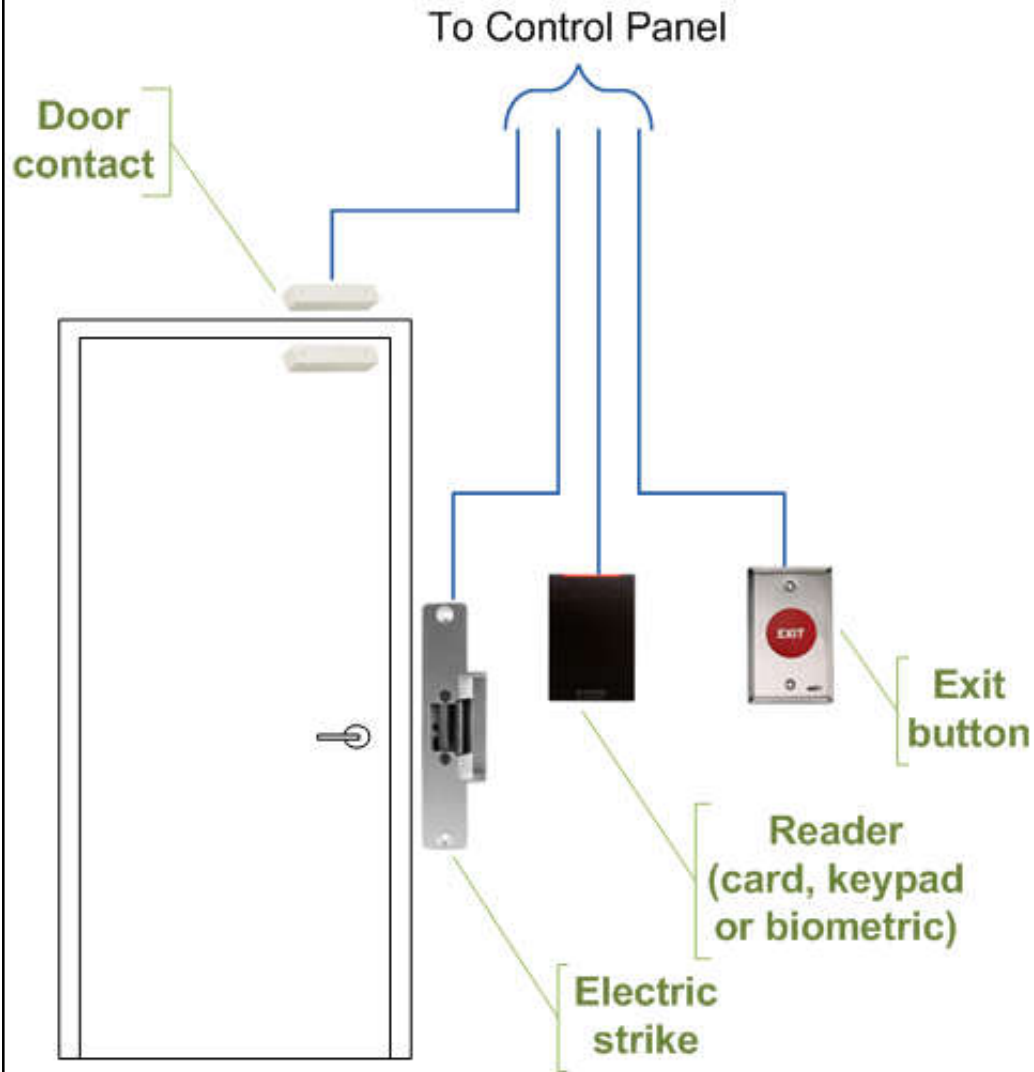
(a) With basic (non-intelligent) reader
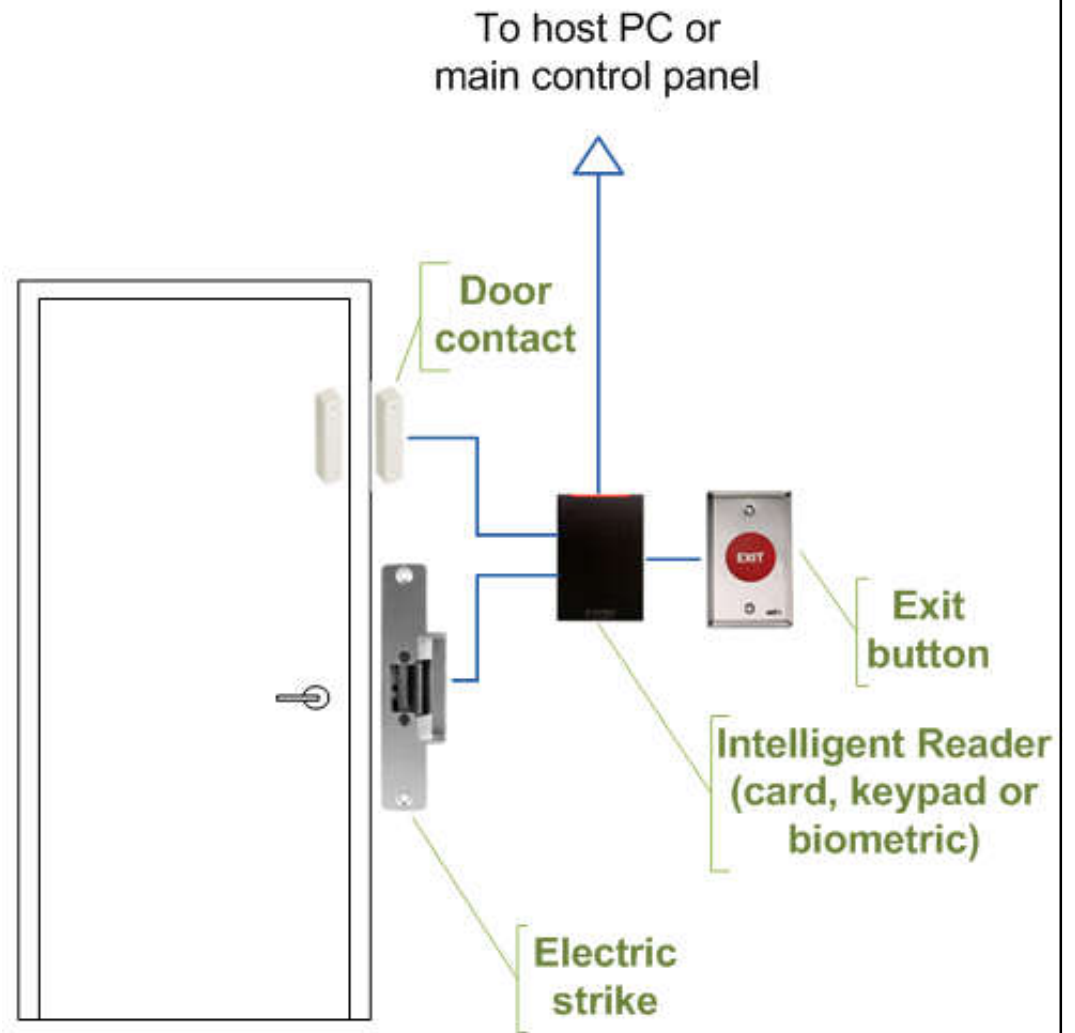
(b) With intelligent reader

Access control system using IP controllers

Ethernet hub or switch

Host PC

To other IP controllers

Cat5 network cable

IP controller

IP controller

How to integrate access control with fire alarm systems

Central power supply

Relay control

Controlled 12 VDC power to all the locks

NC

Electric Lock

Coil of Relay

+V DC

IP Reader

Fire Control Box

Lock Control

Network with PoE

EXIT

This diagram assumes that the output from the Fire Alarm Box provides a GND connection when the alarm occurs. It must provide enough current to drive the coil of the relay. The relay is connected from COM to NC (if Form-C relay).

This configuration also assumes that the electric locks are either a mag lock, or a strike that is set for "fail-safe".

(Source: https://kintronics.com/access-control-fire-alarm-system-integration/)

Architecture of an access control system with network support

Alarm Processing Workstations

Multi-channel Network

Video Monitors

Video router/switch

Control Panel

Alarm Horn

Video Recorder

Badging Server

Access Control Server

Reader

Door position Sensor

Crash Bar & strike

CCTV Camera

Body Scanner Server

Request to Exit

Electric strike control

Panel-door wires:
Reader 7,
door status 2,
Rex 2,
strike power 2,
strike actuator 2

Body Scanner

Dashed line represents one Access Point and typical devices

(Source: https://diamondlockandsecurity.com.au/)

Access control systems

- Integrate access control systems with BAS
  - Provide information regarding location of building occupants & how they move throughout a building
    - This can assist with energy efficiency, traffic flow management & occupant safety during emergency
  - Can be used to activate many BAS processes (e.g. turn on lights) when the staff enters the building
  - Make command & control actions work efficiently while ensuring the command is coming from the right credentials (to protect the assets)

Access control systems

- Intercom systems
  - Audio intercoms
    - One to one connections (two-way audio)
    - Many intercoms to a central control centre
  - Video intercoms
    - One intercom to one or many connections (e.g. smartphones & a central computer)
    - Integrate with IP camera systems & door access control systems to provide a complete security system
  - Visitor control systems (e.g. a delivery person)
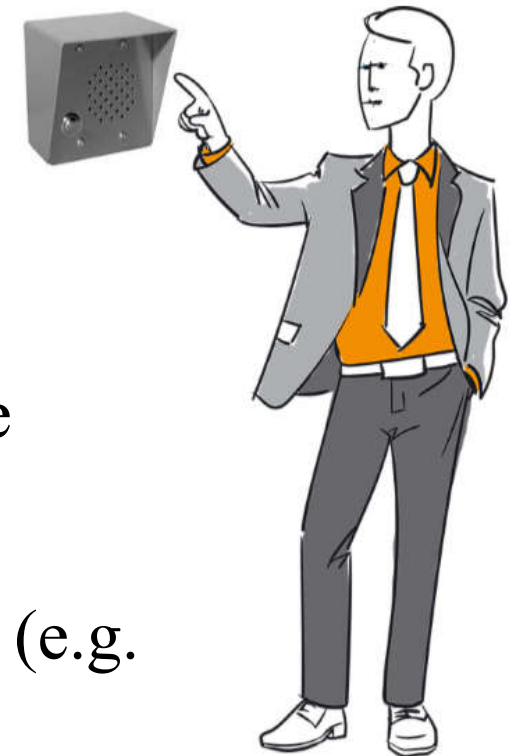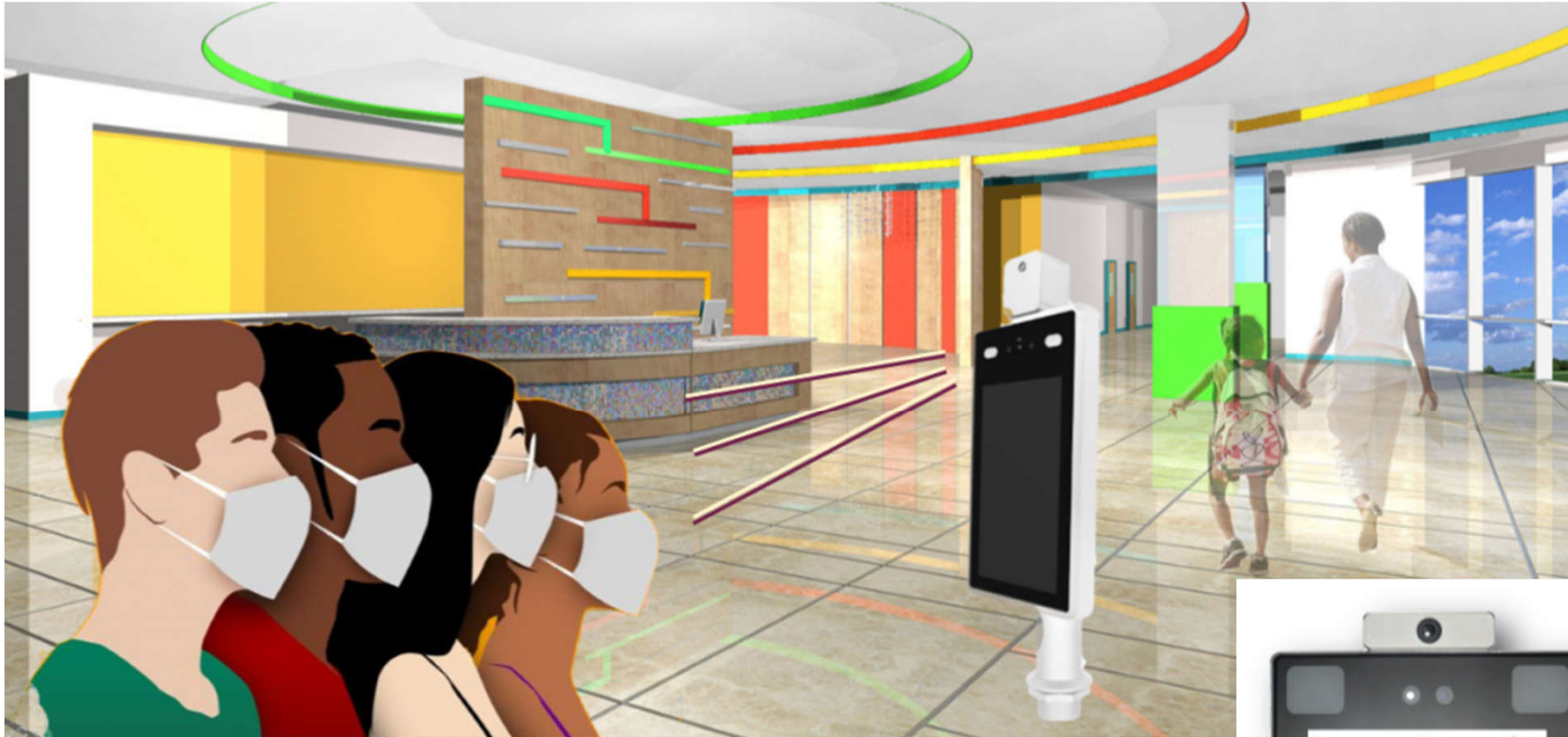
Audio intercoms for door access control

IP Intercoms

Computer running
Talkmaster Intercom
Software

Network
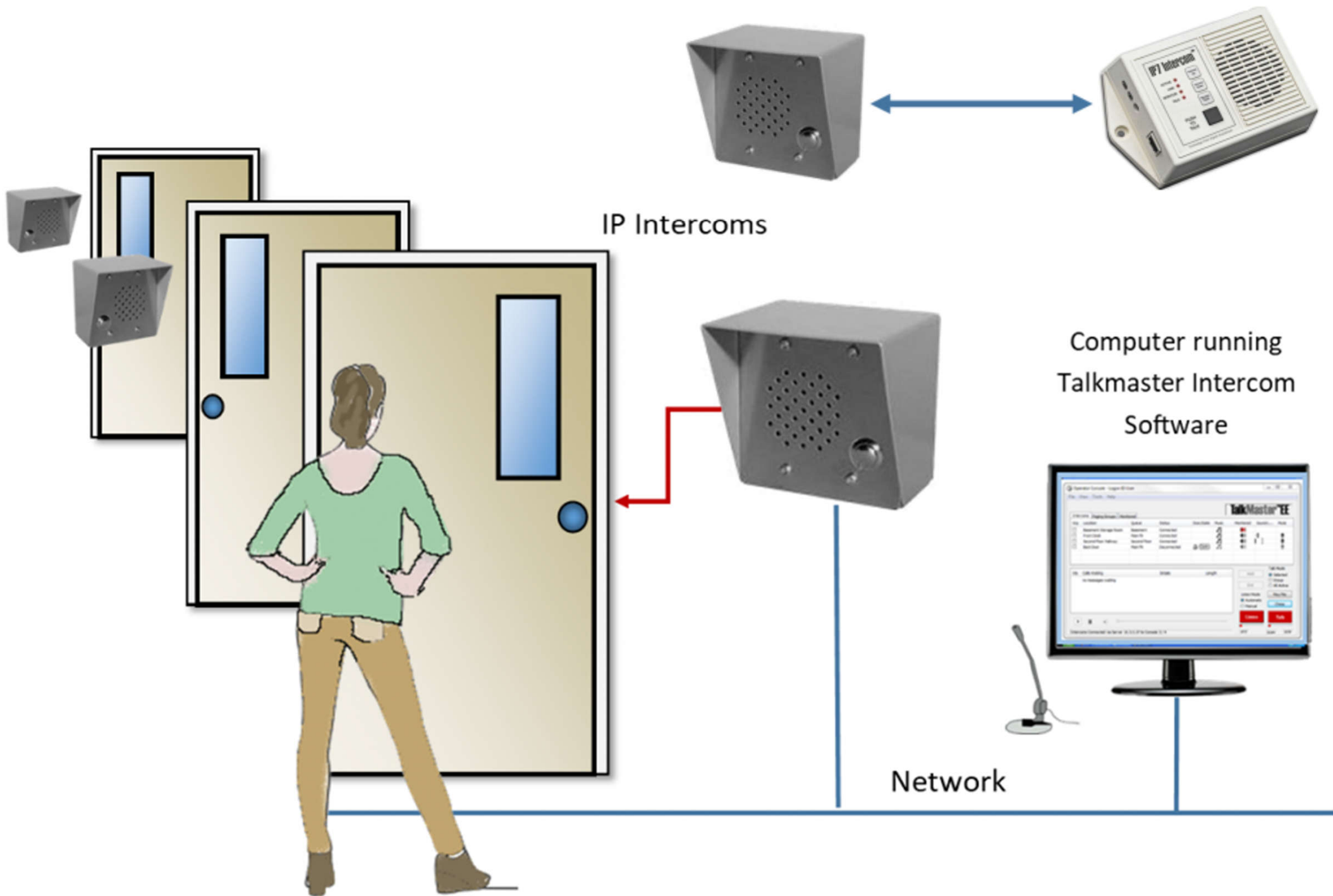
Video intercoms & smartphone communication

Biometric & body temperature access control
(check a person's temperature and check if they are wearing a mask)
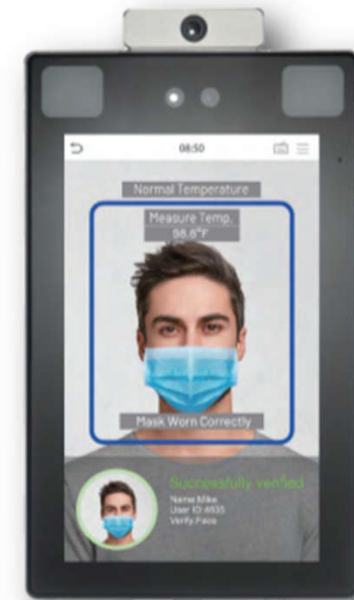
Video: Access Control with Temperature Monitoring (1:44) https://youtu.be/w49T2gpbz8Q

Burglar & intruder alarms

- Burglar alarm system include:
  - Control panel
  - Keypads
  - Intruder detectors & motion detectors (e.g. passive infrared, microwave, or photoelectric)
  - Door & window magnetic contacts
  - Alarm bells or siren
  - Central monitoring station/company (optional)

Basic approach of an alarm system

Input	Control	Output
Sensors	**Panel**	**- Bell, siren, light** **- Dialer, email** **- Police-connect**
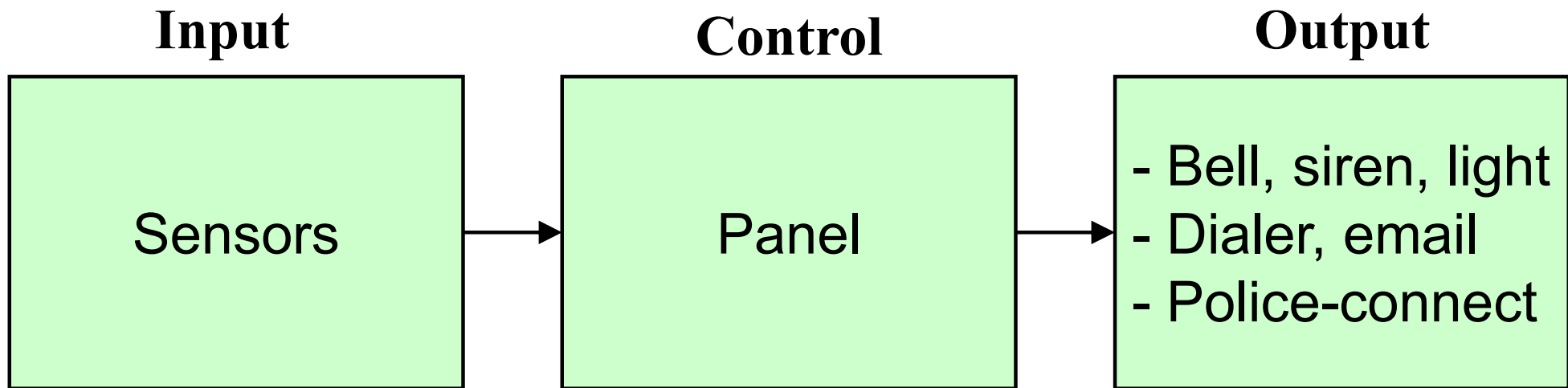
Detection sensors:
- Infrared
- Ultrasonic
- Microwave (droppler effect)
- Dual technology
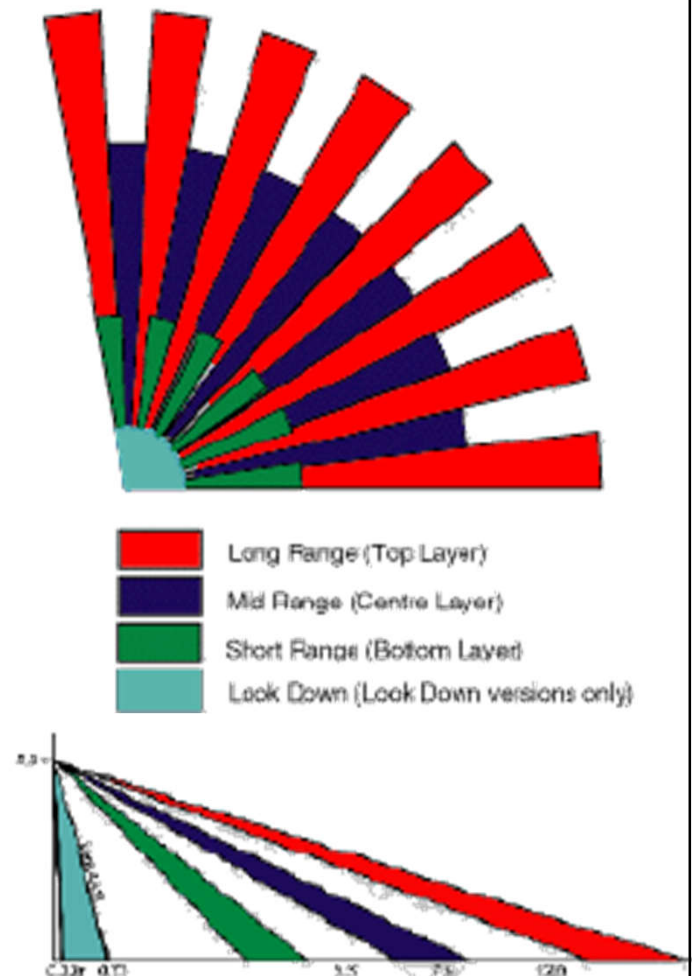- Glass breaks, switches

Annunciation/
alarm signaling

Burglar & intruder alarms

- Intruder detection alarm system

  - Mechanical contact switch

  - Magnetic contact switch

  - Glass-break & vibration detector

  - Photo-electric sensors

  - Motion sensors

    - e.g. passive infrared (PIR) sensors

  - Signaling devices

    - Both audible & visual types

Long Range (Top Layer)

Mid Range (Centre Layer)

Short Range (Bottom Layer)

Look Down (Look Down versions only)

Example of an intruder detection alarm system

Components of intrusion detection alarm systems

- smoke detectors that detects smoke and sounds alarm to warn entire family.
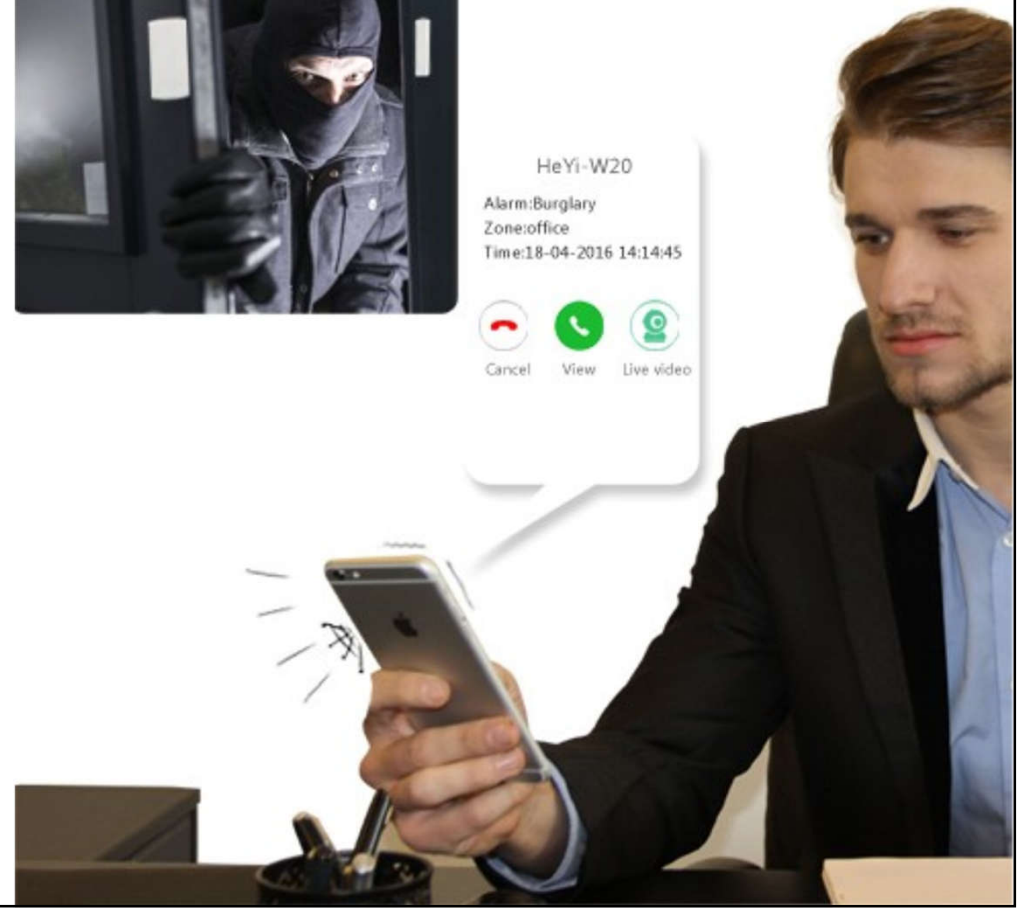
window/door contacts

-motion detectors

-Interior Siren

(Source: https://lotussecuritysolutions.com/intrusion-detection-alarms/)
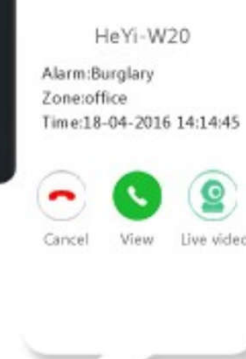
Burglar & intruder alarms

- Additional items to the basic system
  - Smoke detectors
  - Glass break detectors
  - Panic buttons
  - Pressure mats
  - Closed circuit TV
  - Alarm screens
  - SMS alert service !! →

HeYi-W20

Alarm:Burglary
Zone:office
Time:18-04-2016 14:14:45

Cancel   View   Live video

Further reading

- CCTV - Designing Buildings Wiki
  https://www.designingbuildings.co.uk/wiki/CCTV

- Introduction to Access Control Systems
  https://www.silvaconsultants.com/intro-to-access-control-systems

- Introduction to Intrusion Alarm Systems
  https://www.silvaconsultants.com/intro-to-intrusion-alarm-systems

- Basic information on intruder alarm systems
  https://www.dipolnet.com/basic_information_on_intruder_alarm_systems_bib770.htm