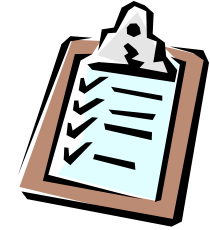智能大廈科技

Smart Security & Safety

Ir Dr. Sam C. M. Hui
Department of Mechanical Engineering
The University of Hong Kong
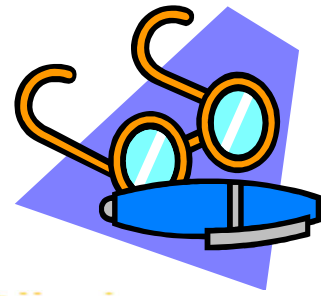E-mail: cmhui@hku.hk

Jan 2024

Contents

- Basic principles

- Major components

- Video surveillance

- Access control

- Burglar & intruder alarms
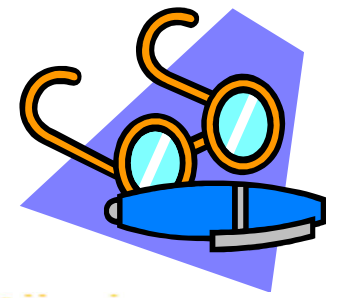
Basic principles

- Security & safety/protection systems
  - To guard persons & property against a broad range of hazards, including crime, fire, accidents, spying, sabotage, subversion & attack
    - <u>Personal safety</u> of people in the organization, e.g. employees, customers or residents
    - <u>Tangible property</u>, e.g. the plant, equipment, finished products, cash & securities
    - <u>Intangible property</u>, e.g. highly classified national-security information or "proprietary" information (e.g. trade secrets) of private organizations

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

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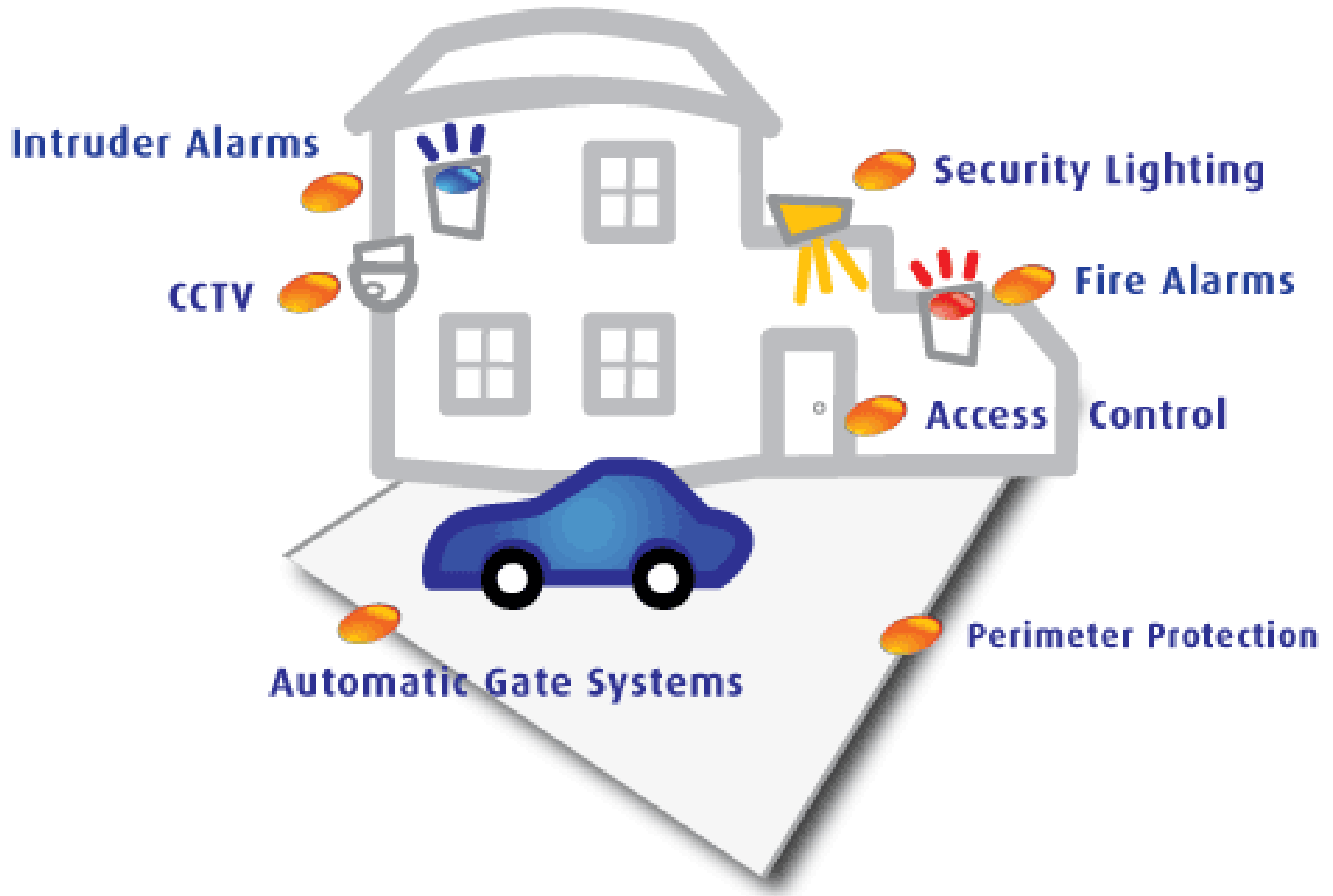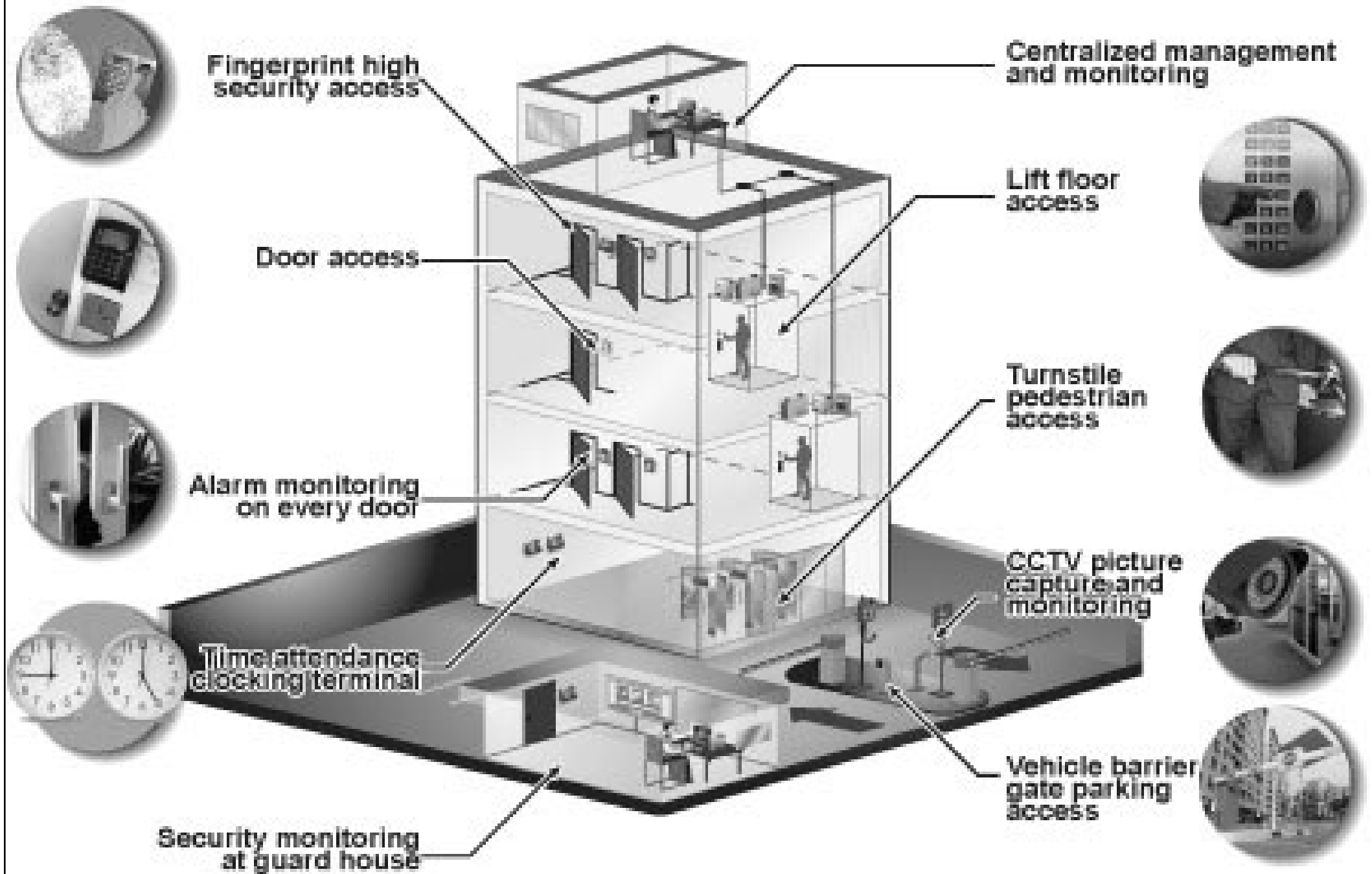
Basic principles
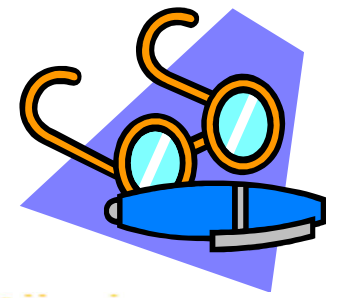
- Common types of security systems:
  - Burglar alarm system (central or local)
  - Closed circuit television (CCTV) surveillance
  - Intruder detection & access control
  - Intercom systems (audio/video)
  - Door-phone system & interlocking system
  - Panic attack (PA) button & sound system
  - Security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

Common security & alarm systems

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

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)
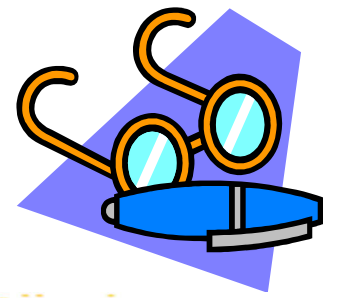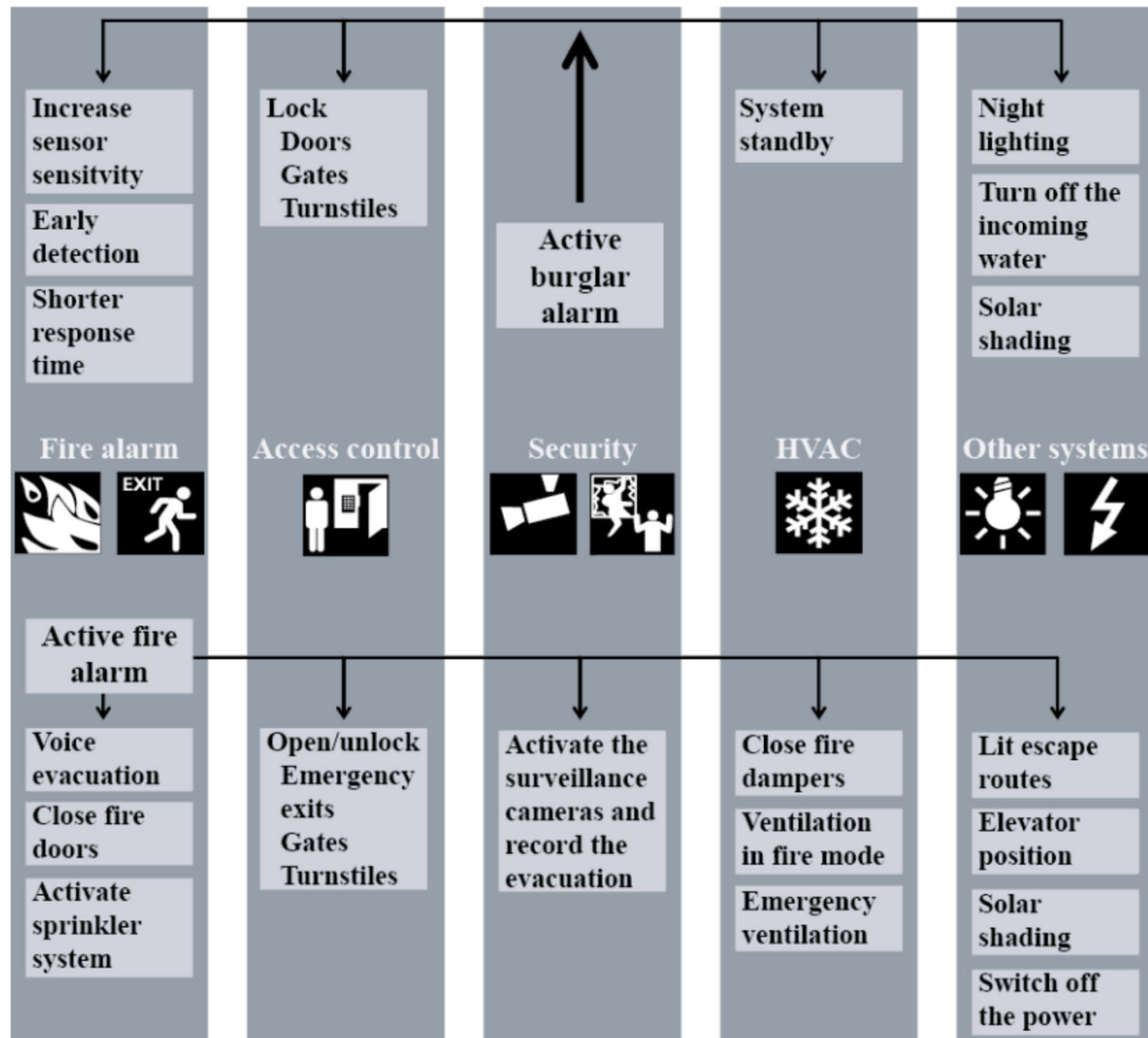
Basic principles

- Security systems are becoming increasingly automated & integrated, e.g. in sensing & communicating hazards & vulnerabilities
  - This is true in both crime-related applications, e.g. intrusion-detection devices, and fire-protection alarm & response (extinguishing) systems

- Types of security systems
  - Residential, commercial, retail, industrial, etc.
  - Theft control, fire protection, accident prevention, plant protection

Functions of building automation system (BAS)

Fire & security

24/7 Monitoring

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]

Example of burglary & fire alarm with integrated functions in BAS

Fire alarm	Access control	Security	HVAC	Other systems
Increase sensor sensitvity; Early detection; Shorter response time	Lock Doors Gates Turnstiles	Active burglar alarm	System standby	Night lighting; Turn off the incoming water; Solar shading
Active fire alarm				
Voice evacuation; Close fire doors; Activate sprinkler system	Open/unlock Emergency exits Gates Turnstiles	Activate the surveillance cameras and record the evacuation	Close fire dampers; Ventilation in fire mode; Emergency ventilation	Lit escape routes; Elevator position; Solar shading; Switch off the power

(Source: Siemens Building Technologies, Inc.)

Typical components of security & alarm systems

Intrusion Alarms

Closed Circuit Television

Digital Video Surveillance

Access Control

Critical Process Monitoring
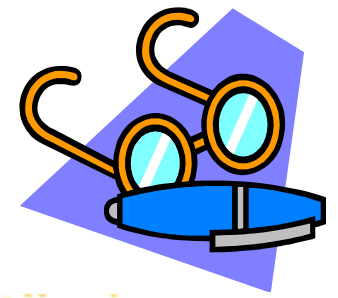
Basic principles

- Basic components of smart security:
  - Camera, voice sensor/microphone, motion/activity sensor, LTE/Wi-Fi module, controller

- Typical functions:
  - Simple & effective ease of installation
  - 24/7 real-time monitoring & remote control
  - Prevent & detect crime (theft, robbery or burglary)
  - Get alerts & notification in case of emergency
  - Cloud storage, analytics & reporting

Basic concept of smart security system using Internet of Things (IoT)

Features of smart security system for homes or organisations

Emotion/Behaviour Analytics

Inventory/Logistics Analytics

Motion Detection Analytics

Face Detection
Hands Detection
Legs Detection

Image & Video Analytics

Smart Security System

Buzzer/Alarm

Audio Analytics

Shock Sensor

Emergency Alerts
Police Station
Fire Station
Ambulance
Nearest Hospitals
Blood Bank

Admin Monitoring
5 Accounts & 5 Users
Regular Notifications
Web App
Mobile App
SMS/MMS
Email
Phone call
Activity Feed (history)

Social Media Alerts
Whatsapp
Facebook
Youtube

Major components

- Key components of smart security systems:
    - 1. <u>Sensors & detectors</u>: Detect potential security threats e.g. motion sensors, cameras & alarms

    - 2. <u>Access control</u>: Control who has access to certain areas or resources

    - 3. <u>Communication & networking</u>: Allow communication between technologies

    - 4. <u>Monitoring & response</u>: Involve human security personnel or automated systems that are able to detect & respond to threats in real-time

Sensors & components of security & building management systems
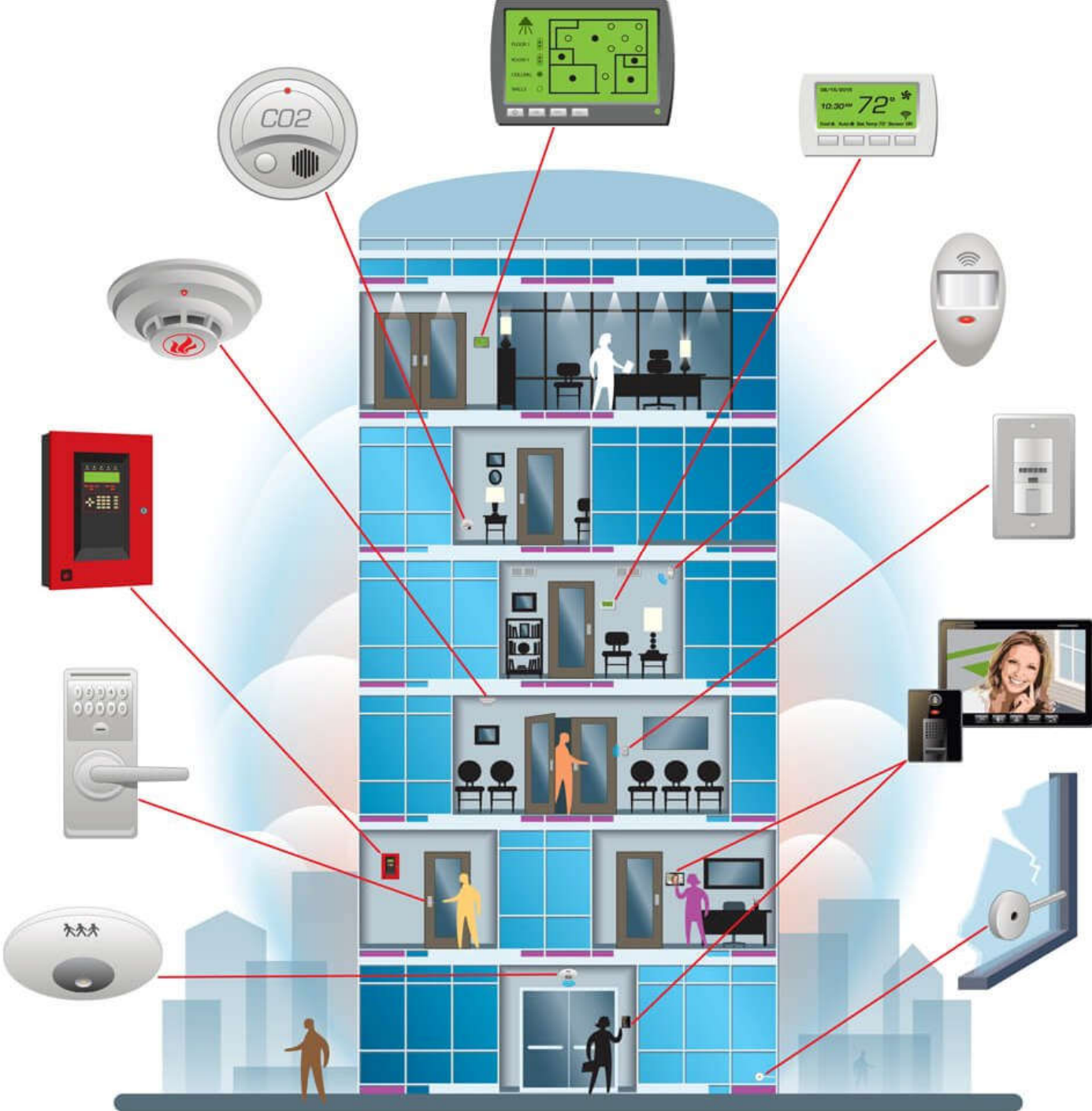
Example of a smart home security system
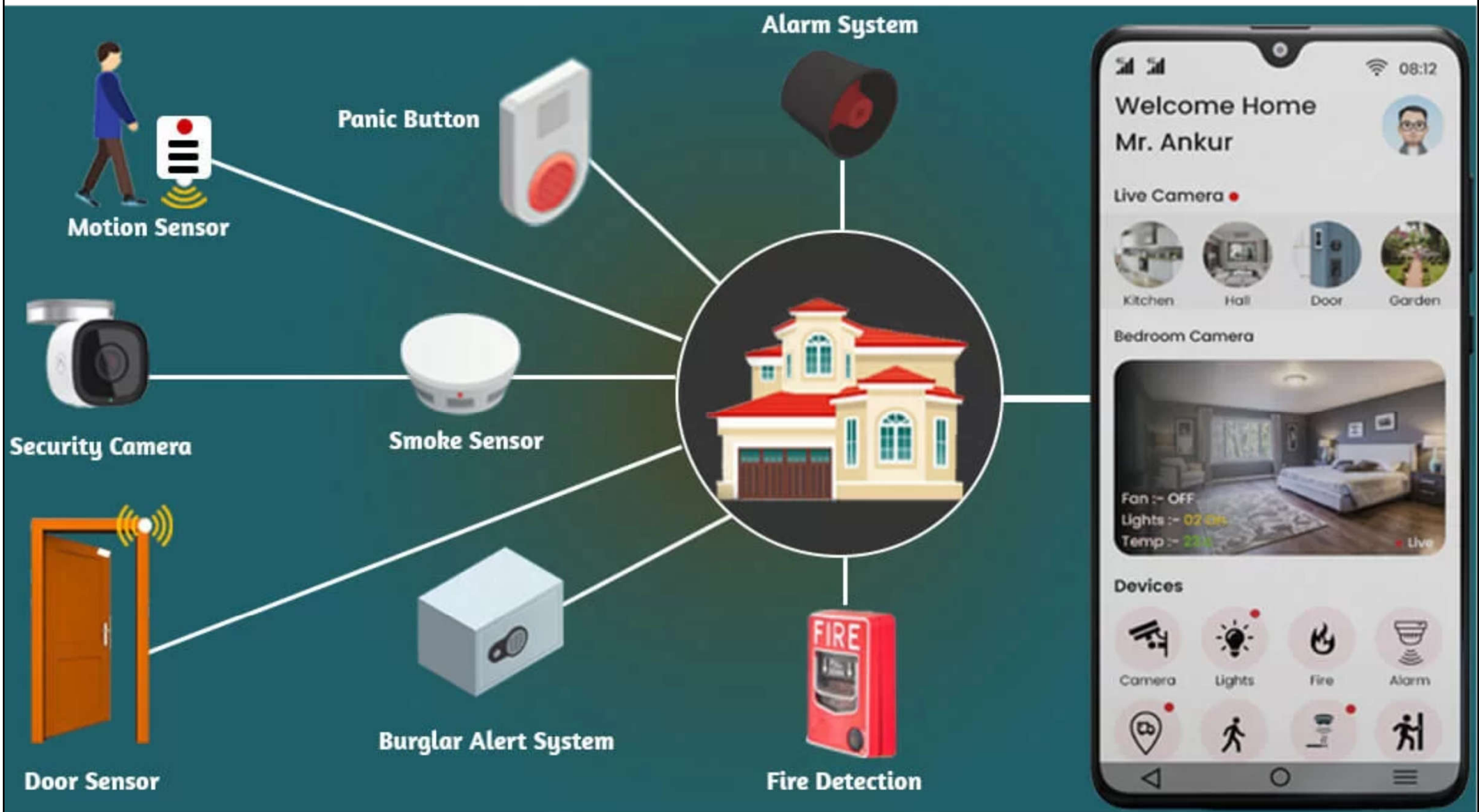
Sensors used in smart home security system
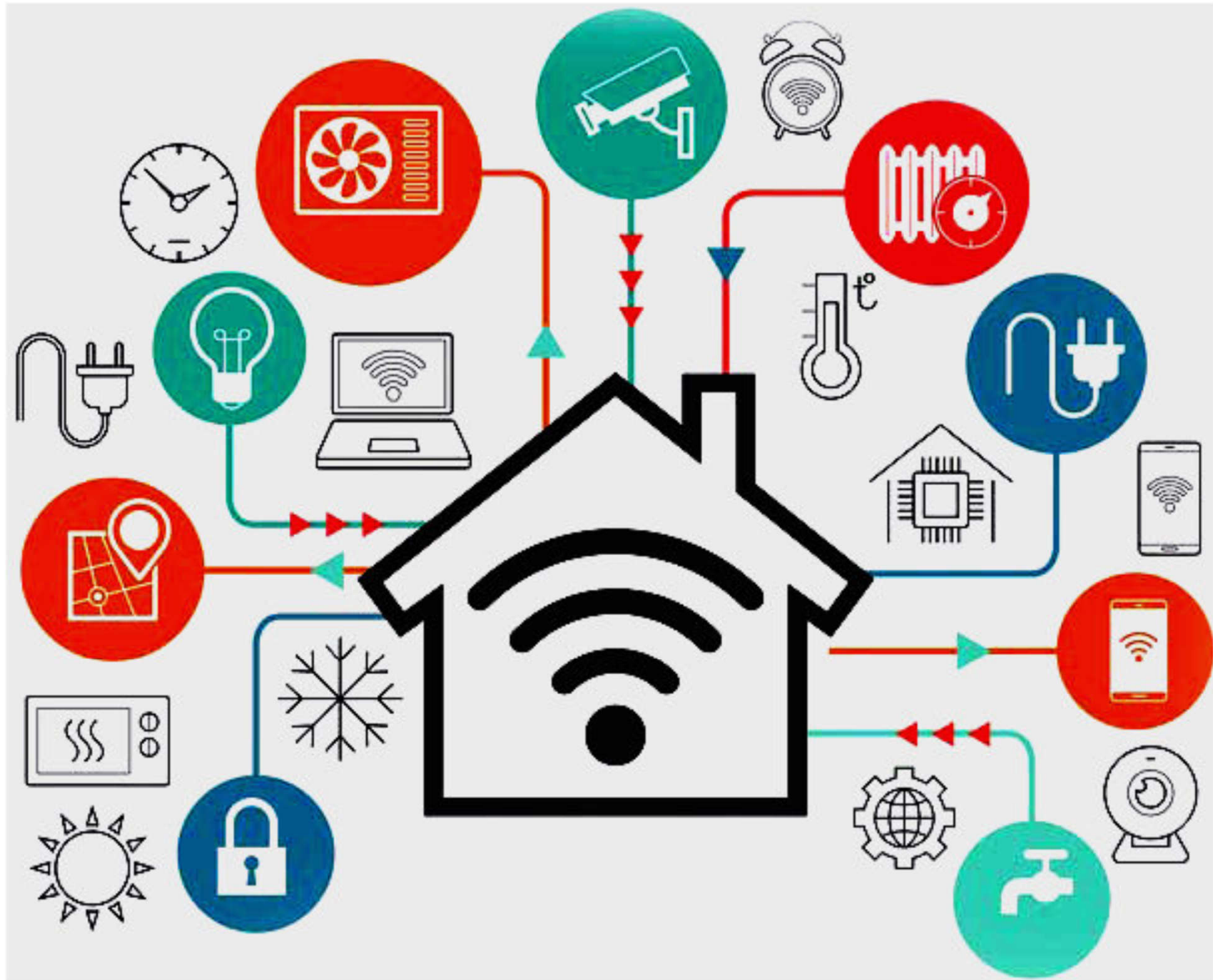
Major components

- 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

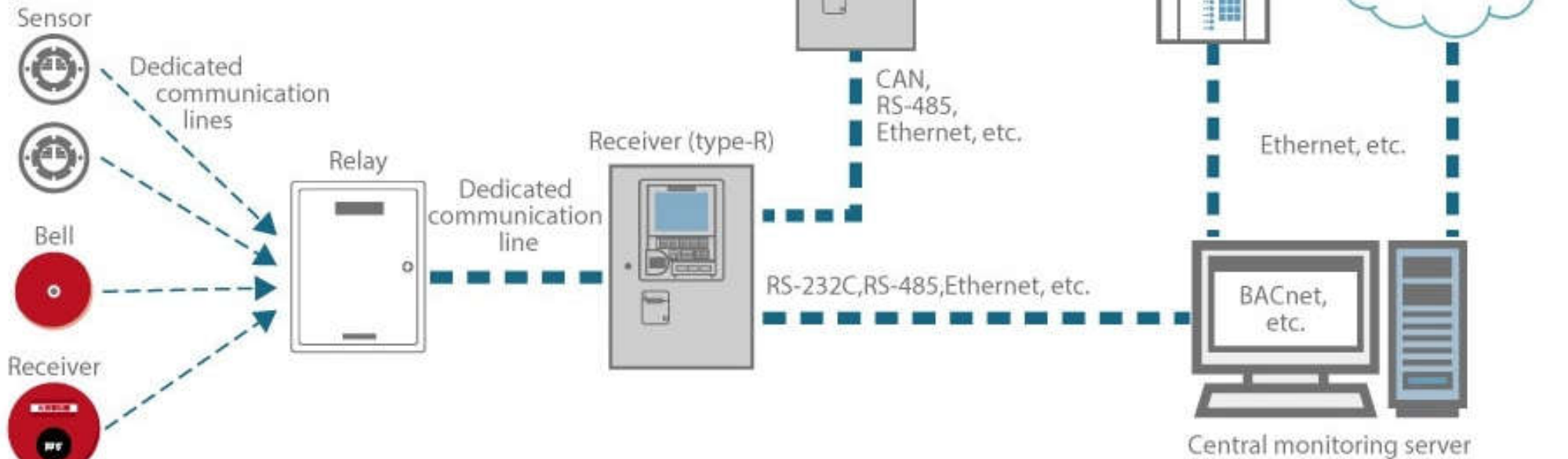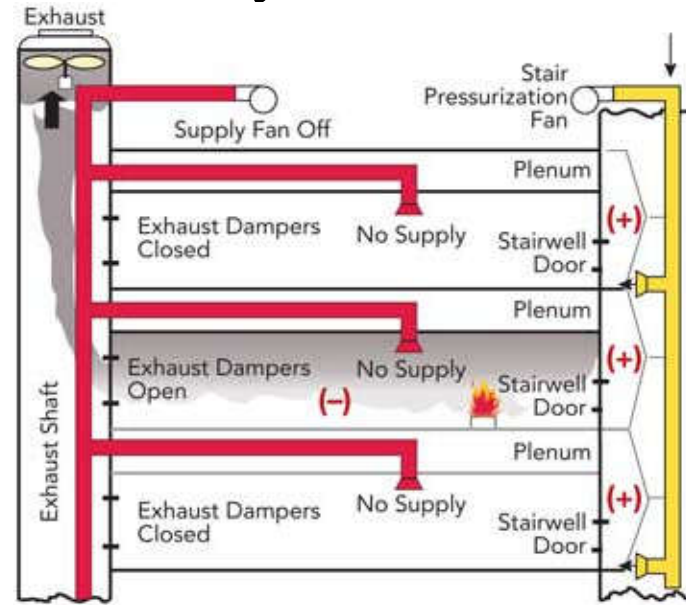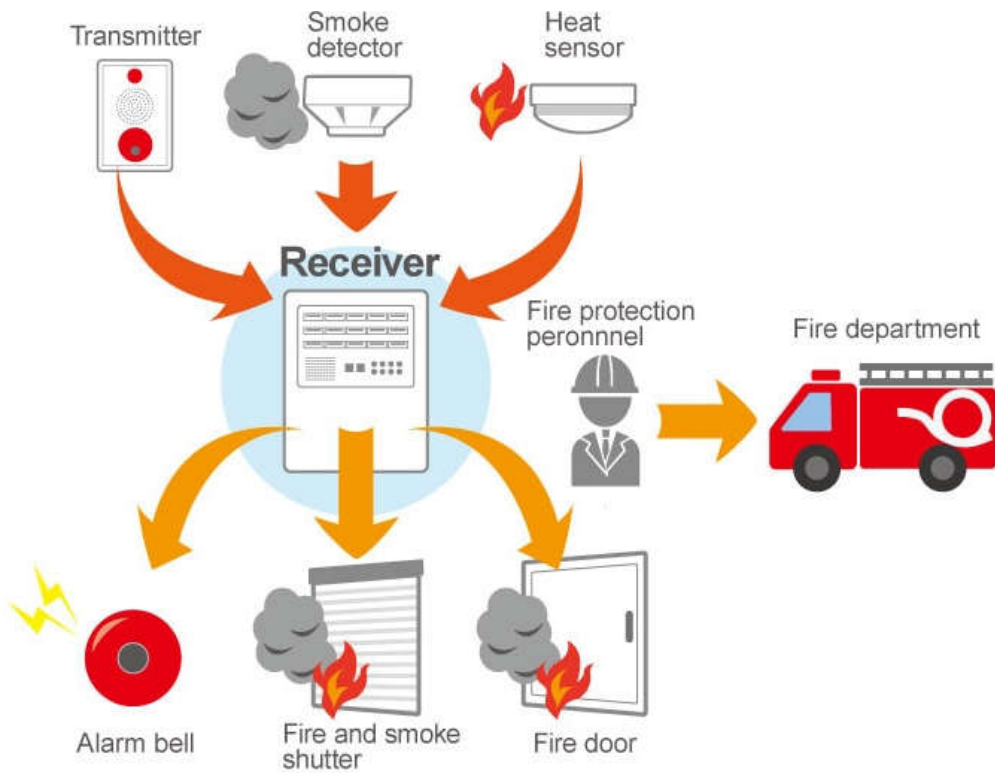# Components of an addressable fire alarm system

Input Devices

- Address button
- Addressable heat detector
- Addressable smoke detector
- Input module
- Smoke detector
- Conventional button
- Heat detector
- Conventional module

Addressable fire alarm panel

24V Source

Output Devices

- Device control module
  - Fire pump
  - Elevator
  - Ventilator
- Output module
  - Flashing light
  - Fire bell

(Source: https://taisei.com.vn/automatic-fire-alarm-system-for-building)

Major components

- 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

Crime prevention & monitoring functions of security systems

(Source: https://www.pinterest.com/pin/300122762684331693/)

Integration of BAS & fire alarm systems

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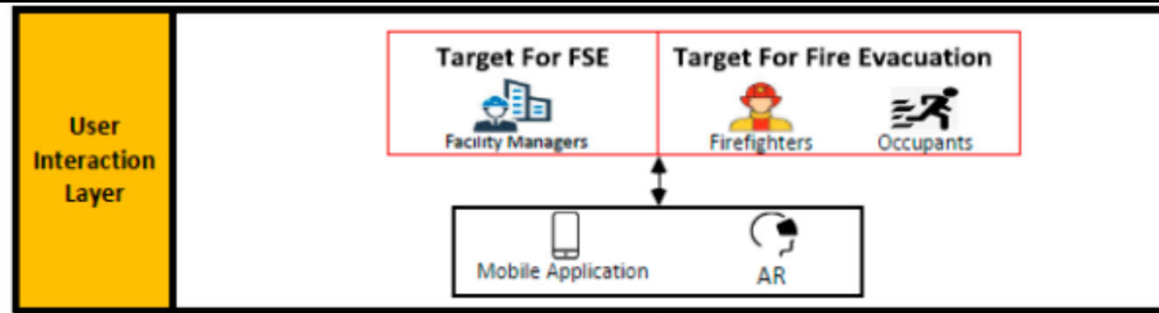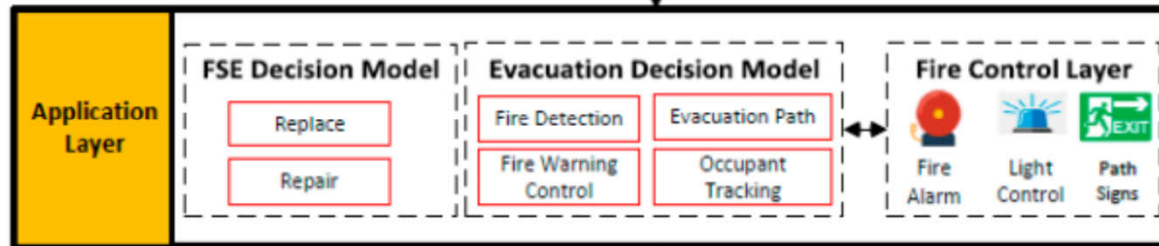
Major components

- Smart fire alarm systems
  - All the components (fire alarms, smoke detectors, sprinkler system etc.) can 'talk' & communicate with each other
  - Various automations can be made to improve the safety of individuals & the site
  - Faults can be detected & alarm activity is captured
  - All the data is accessible & components can be controlled via a smart device, remotely & from anywhere in the world
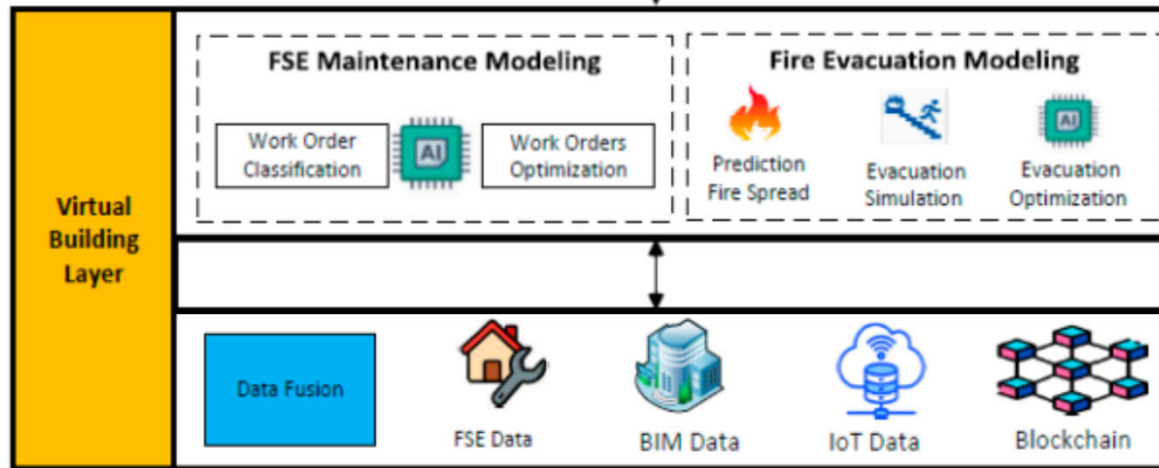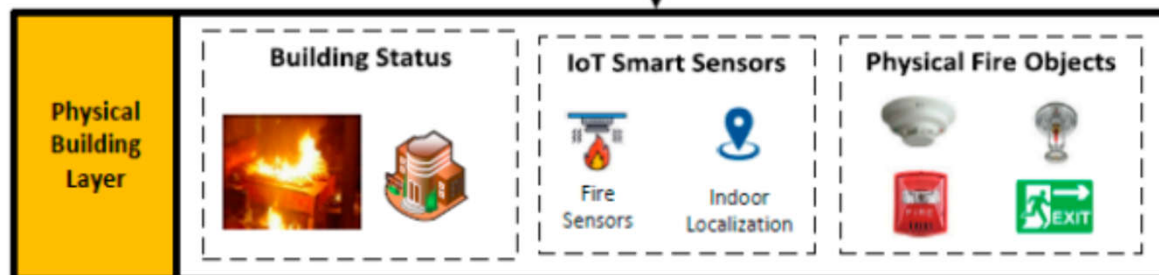
User Interaction Layer
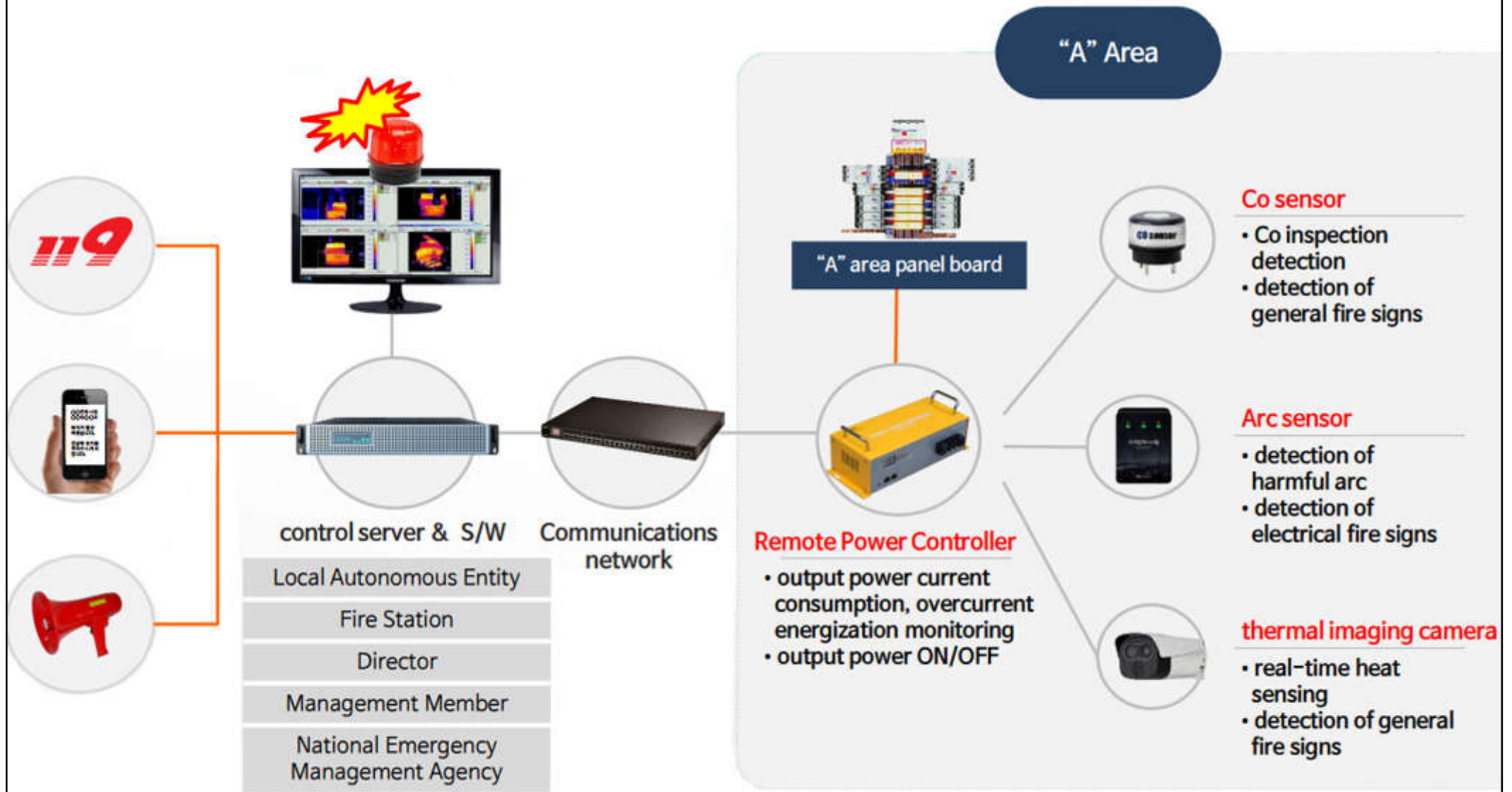
Application Layer

Virtual Building Layer

Physical Building Layer

Smart fire safety framework based on digital twin

Basic concept of a smart fire alarm & detection system

"A" Area

"A" area panel board

Co sensor
- Co inspection detection
- detection of general fire signs

Arc sensor
- detection of harmful arc
- detection of electrical fire signs

thermal imaging camera
- real-time heat sensing
- detection of general fire signs

control server & S/W

Communications network

Remote Power Controller
- output power current consumption, overcurrent energization monitoring
- output power ON/OFF

Local Autonomous Entity

Fire Station

Director

Management Member

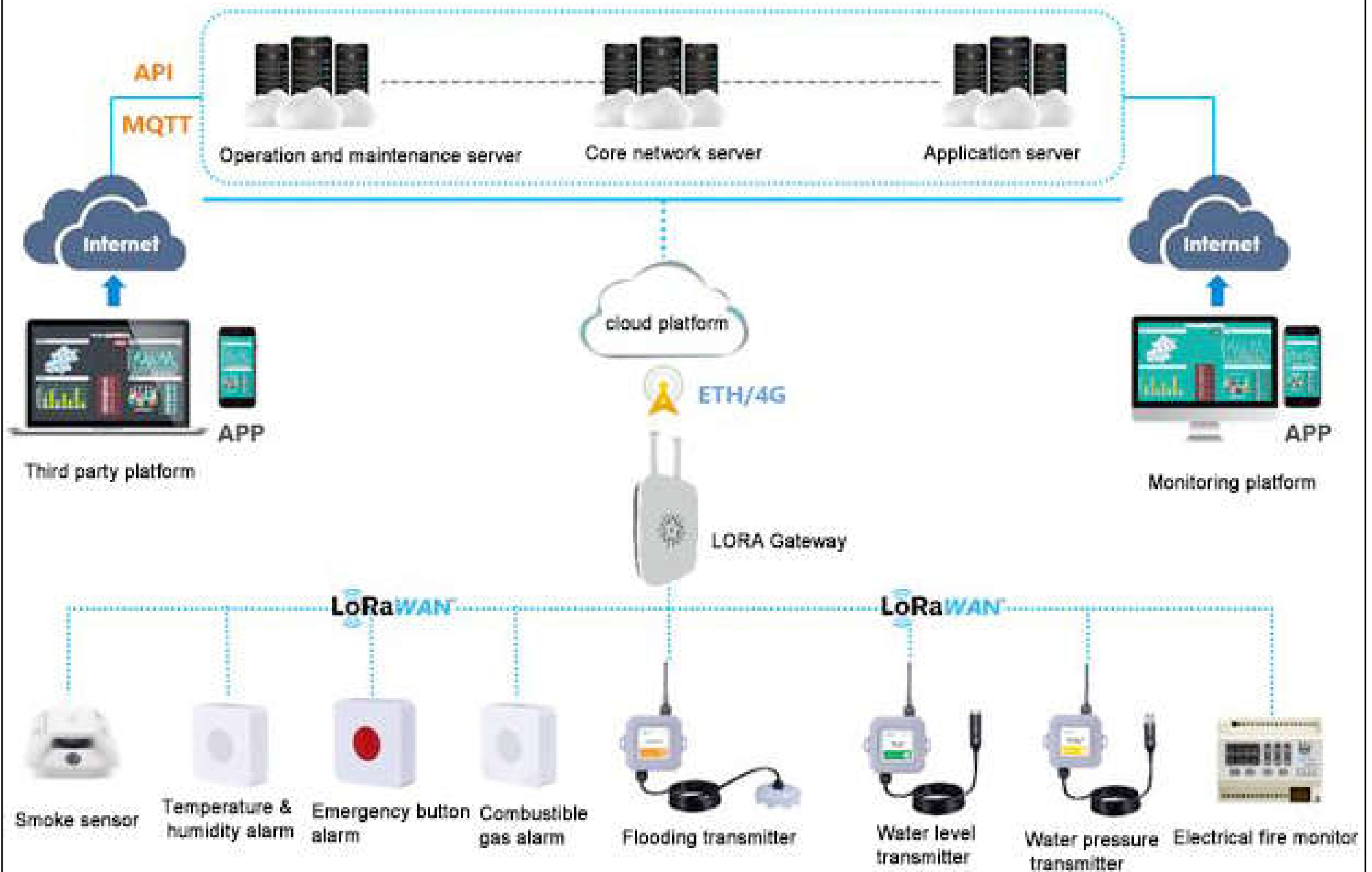National Emergency Management Agency

Major components

- Benefits of smart fire alarm systems
  - Remote diagnostics
  - Automated processes
  - Improved fire protection
  - Energy-saving
  - Remotely access the system
  - Increased system control
- Can integrate with CCTV system & access control to provide more data to improve safety
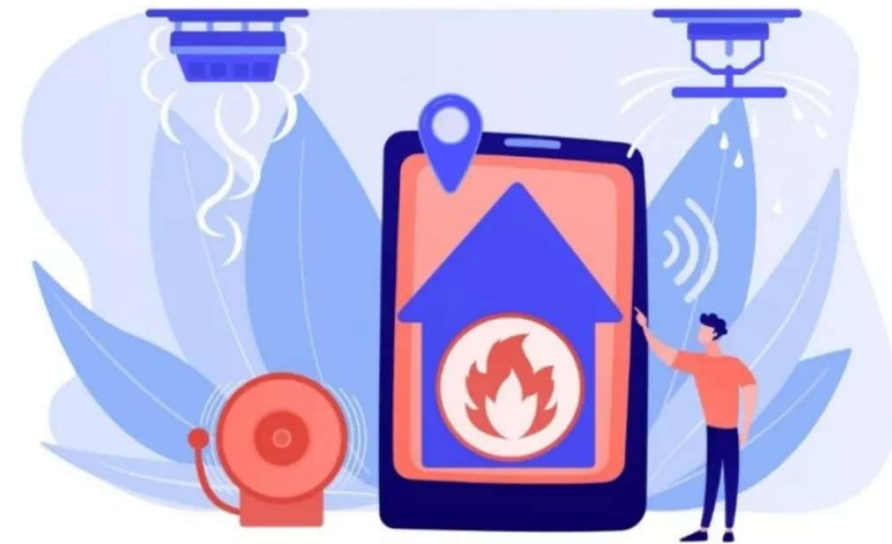
Major components of a smart fire protection system

(Source: https://cdsentec.com/what-is-smart-fire-protection/)

Example of fire panel operations in a smart fire protection system

Hooter

Smoke-cum-heat detector

Heat detector

Smoke detector

Manual call point

Honeywell
Morley IAS Fire Panel

Honeywell
Pub6438s

Honeywell
JACE 8000

Magnetic Locks on the ACS will be disabled

PA System will announce the Evacuation message inside the building

Entry/Exit gates will be opened

Theft alarms in the fire doors will be disabled

eFACiLiTY®

Fire Alarm

(Source: https://www.greenestbuilding.com/smart-building/fire-alarm-system/)

Video surveillance

- 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

Basic concept of a multi-camera CCTV system

Monitor Unit

Lens   Camera   Hard Disk Recorder and multiplexer

Power

Lens   Camera   Coaxial Video Cables

Power

Power   Power

Lens   Camera

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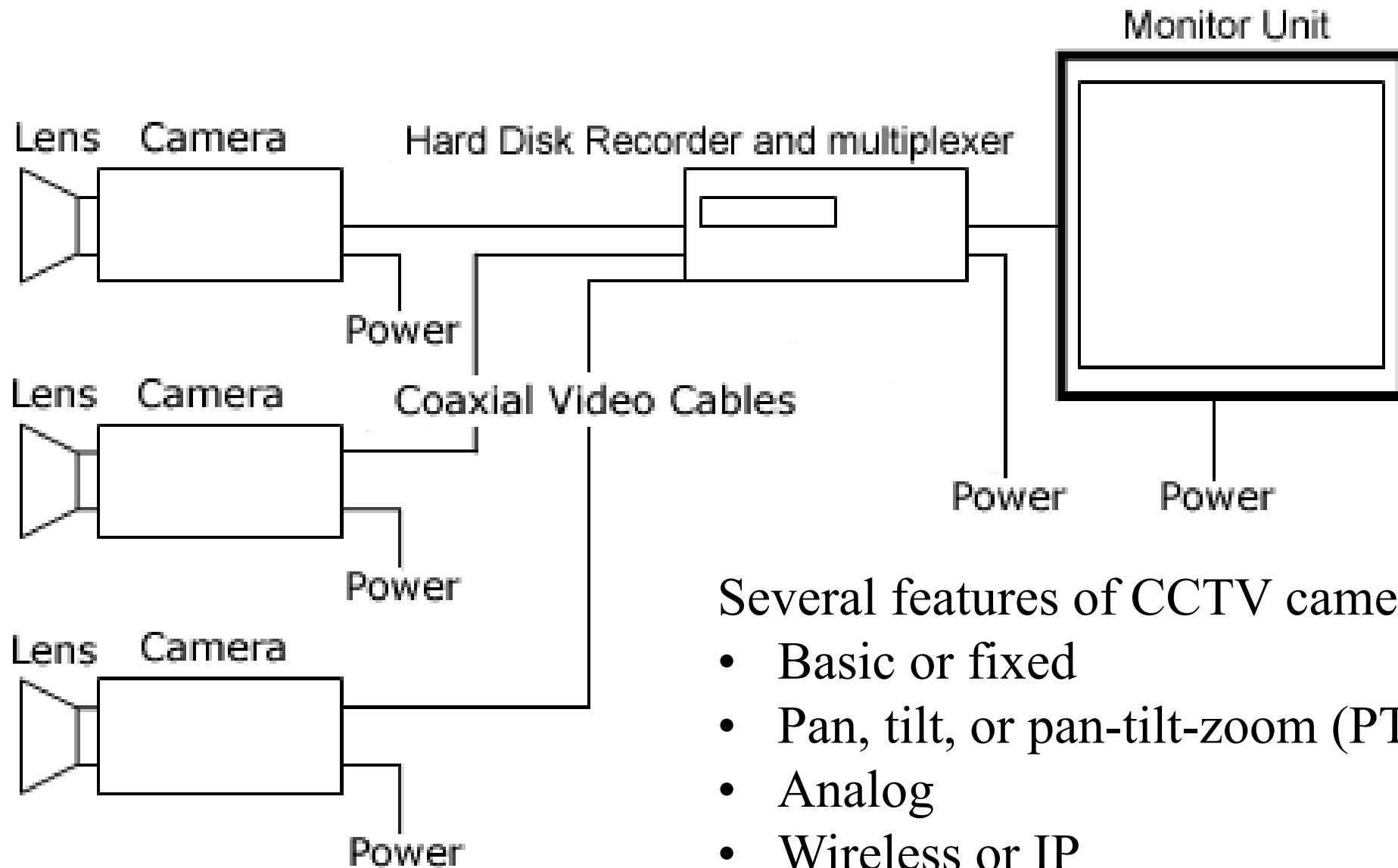
Several features of CCTV cameras:
- Basic or fixed
- Pan, tilt, or pan-tilt-zoom (PTZ)
- Analog
- Wireless or IP
- Night vision
- Exterior
- Motion-detection

(Source: https://ciaalarms.co.uk/cctv/closed-circuit-television-overview/)

Video surveillance

- 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

Smart home security camera system network map
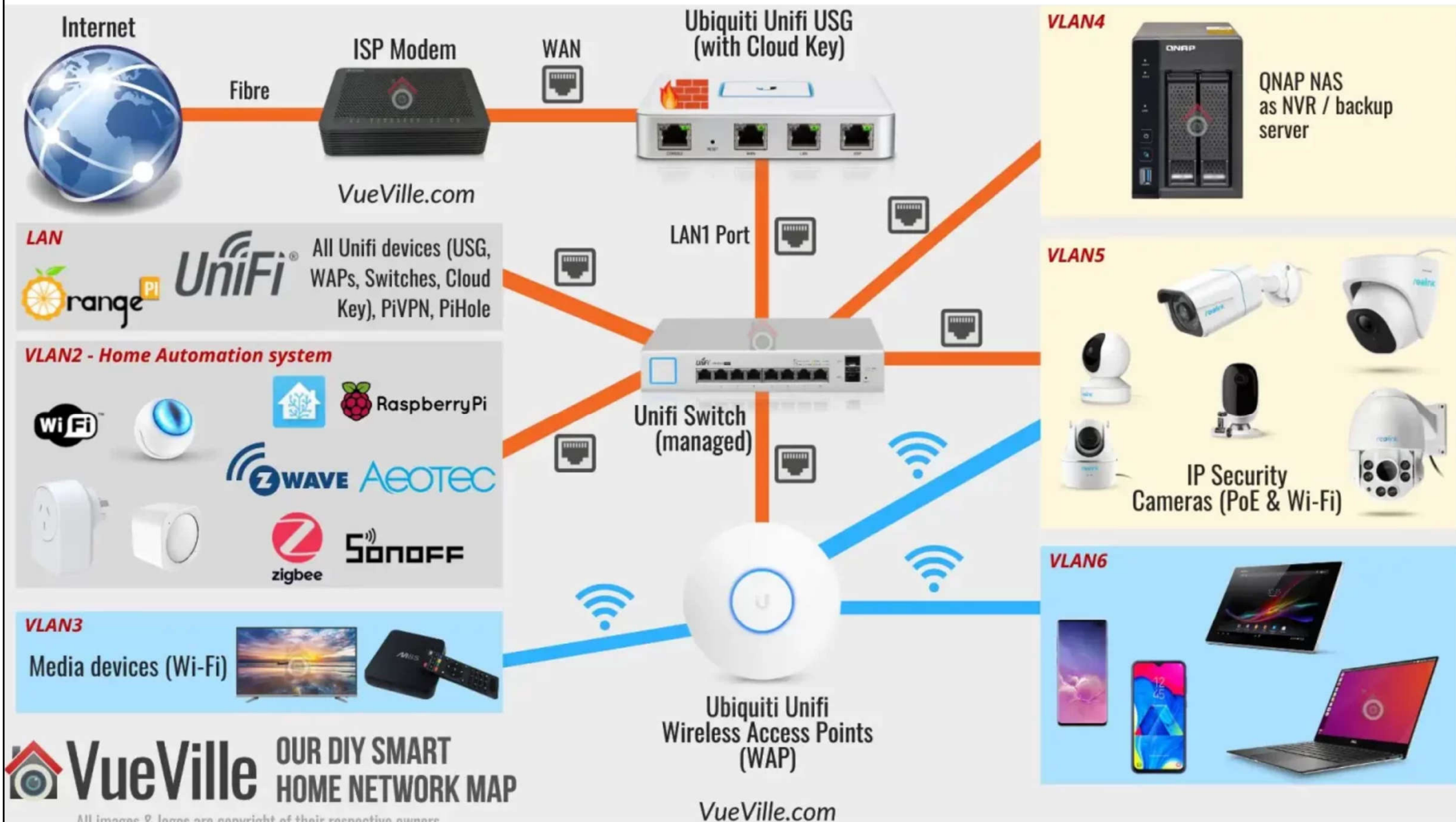
Video surveillance

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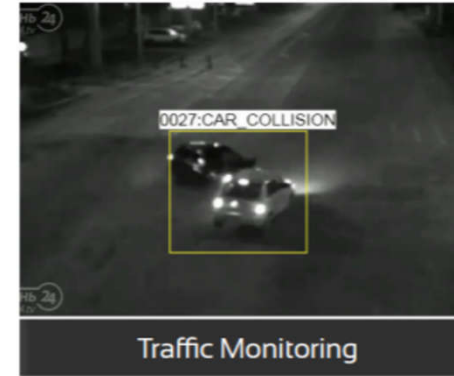
Violent Activity	Suspicious Activity	Person & Crowd Behaviour
• People fighting • Brawl/Riot • Vandalism • Person with blood • Person with weapon	• Contextual loitering, tailgating • Person abandons an object • Person with mask /no mask • Person running/walking/falling • Person gets in/out of a vehicle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

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

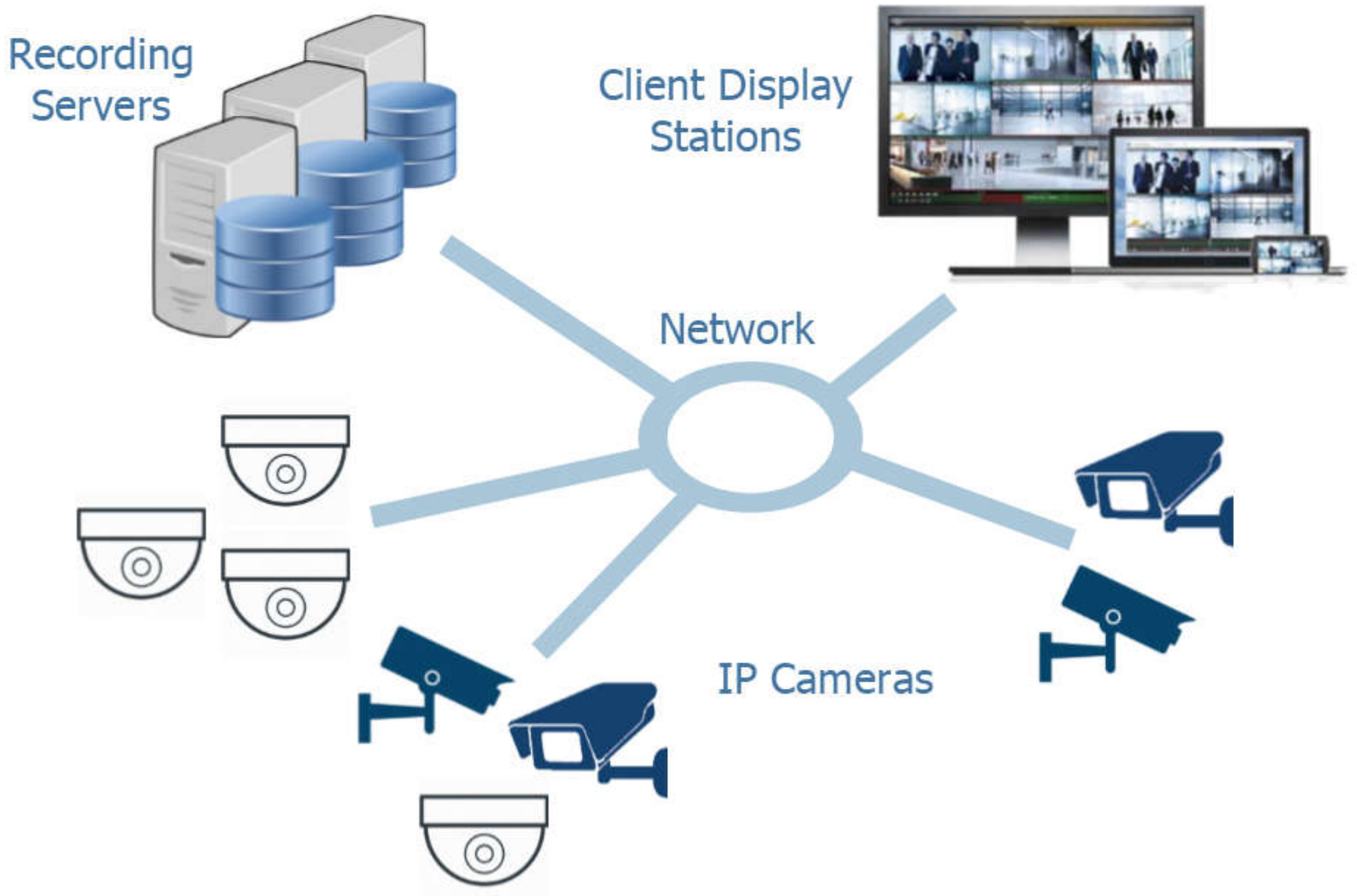(Source: https://www.viisights.com/)
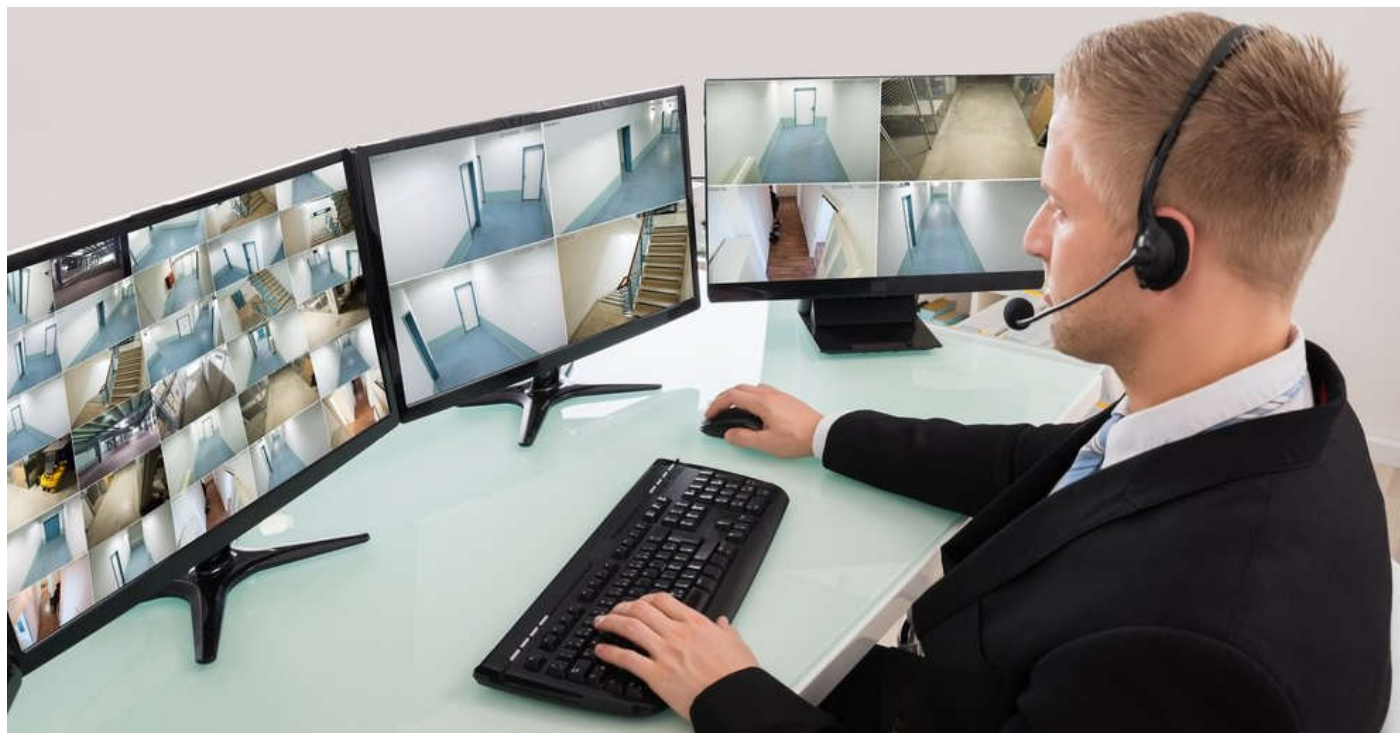
Video surveillance

- 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

(Source: https://kintronics.com/how-to-install-your-ip-camera-system/)

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

Video surveillance

- 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

Video surveillance

- 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)

Internet of Video Things (IoVT): Future of video surveillance systems
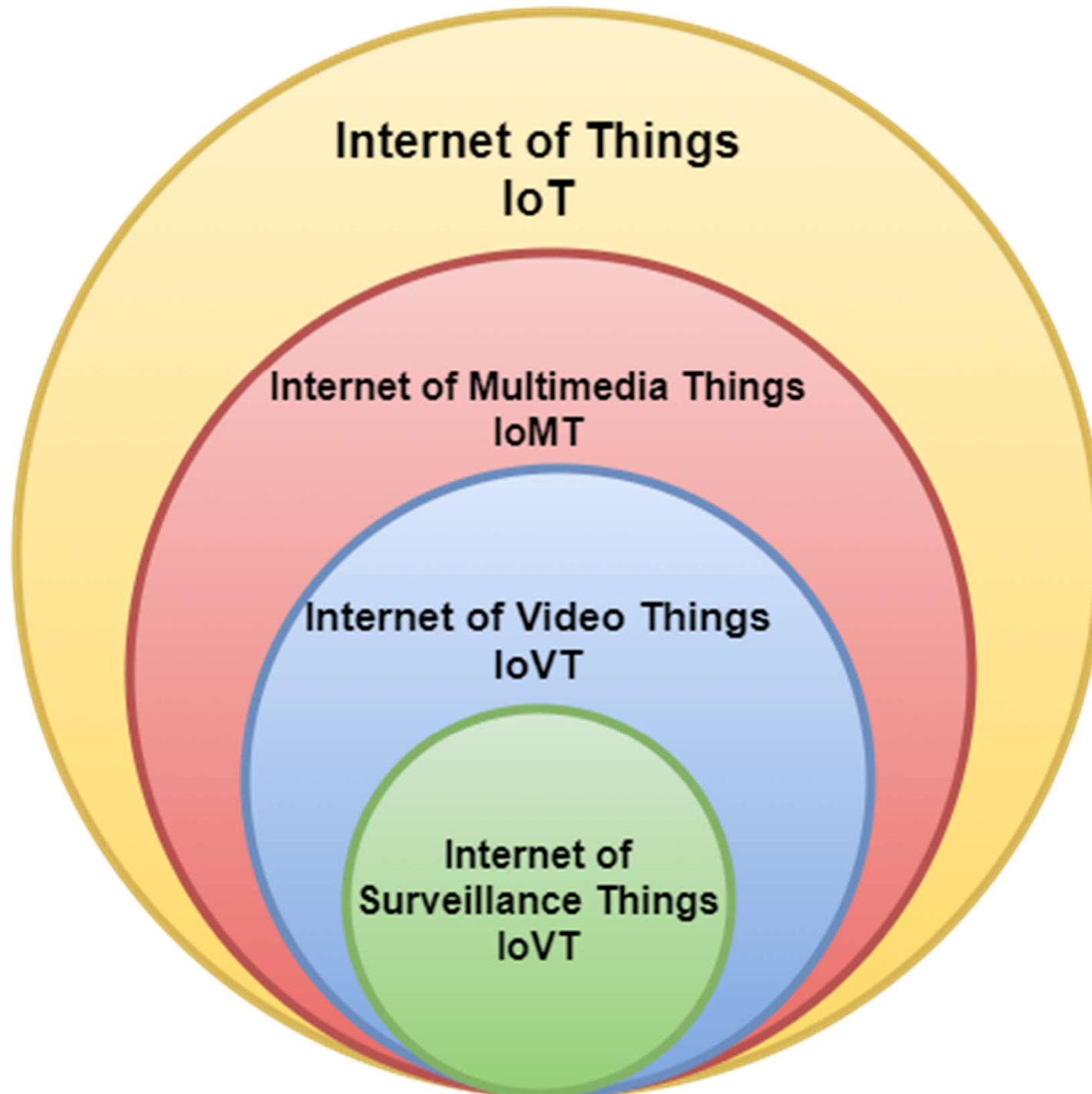
Video surveillance

- Video surveillance & analytics (VSS)
- Key features:
  - People counting
  - Dwell time & loitering
  - Facial recognition
  - Demographics & emotion
  - Forensic search
  - Dynamic masking
  - Heat map analysis
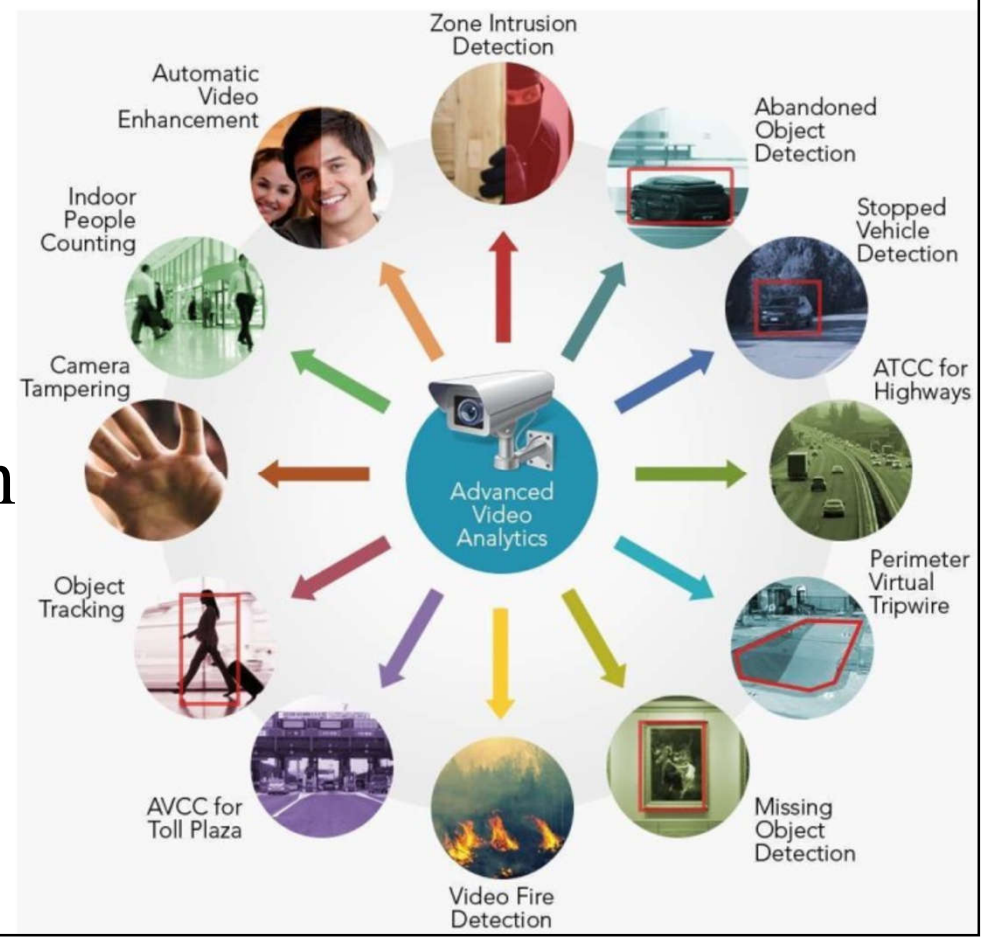
Key features of video surveillance & analytics (VSS)

Dwell time and loitering

Facial recognition
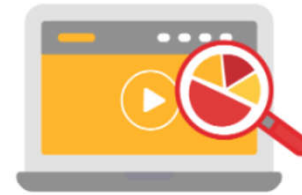
Forensic search

Demographics and emotion analysis

Dynamic masking

Heat map analysis

Motion detection

License plate recognition

Object tracking

Crowd analysis

Queue management

Suspect tracking

(Source: https://www.ricoh.com.hk/en/hybrid-workplace/video-surveillance-and-analytics)

Access control

- Access control system (ACS)

  - Control passage into or out of any area

  - Common 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)

Access Control Terminal

Integrated Photo ID Badge and Access Control System
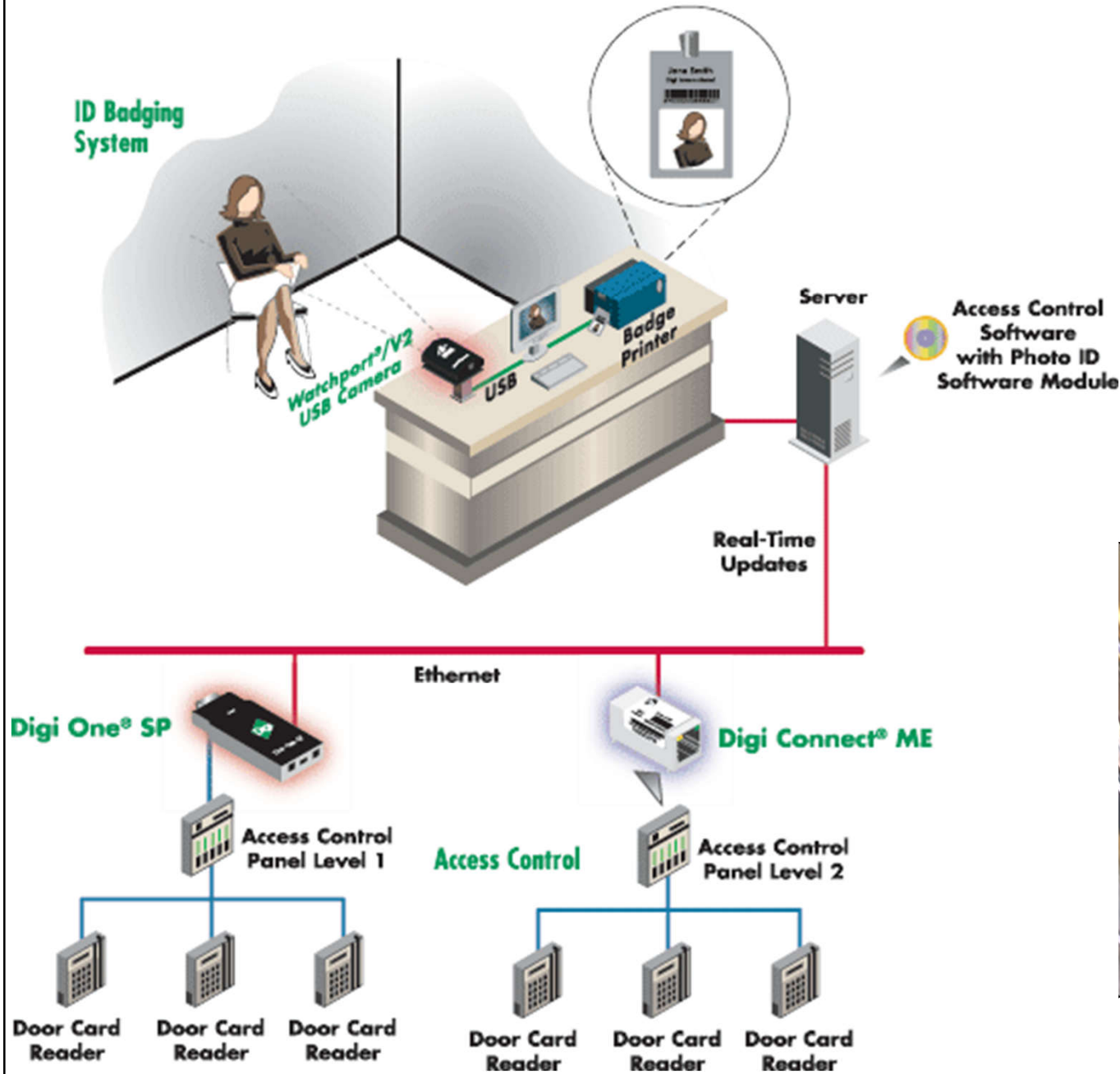
Access control system

Pedestrian turnstiles

Car park control system

Management Office — Network Computer Central Management

Automatic Pay Station

Lag Time Reader

Barrier Gate

PARKING AREA

OUT

Barrier Gate

Ticket Dispenser

IN
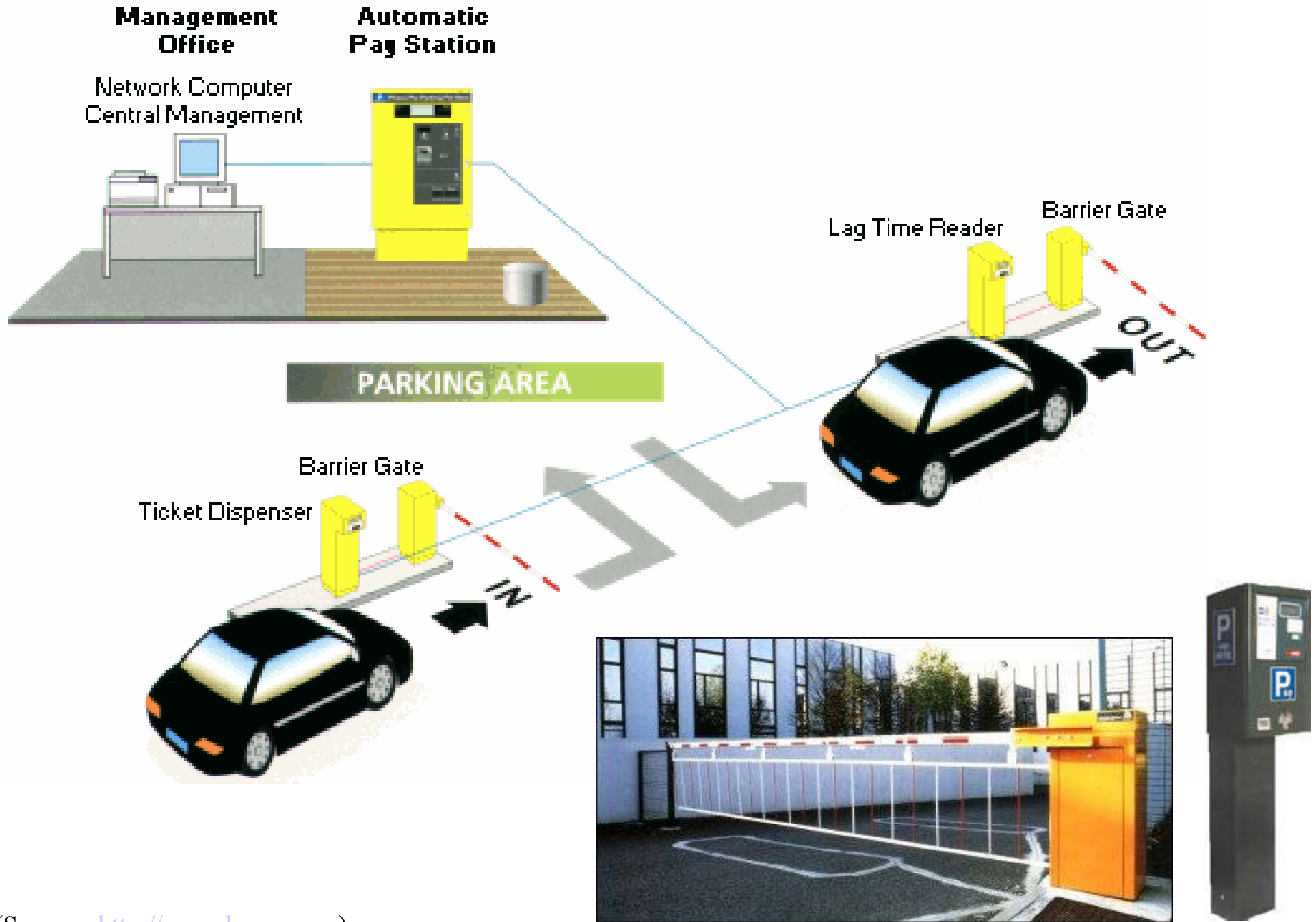
Access control

- Components of access control system (ACS)
  - Stand-alone or online systems
  - 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
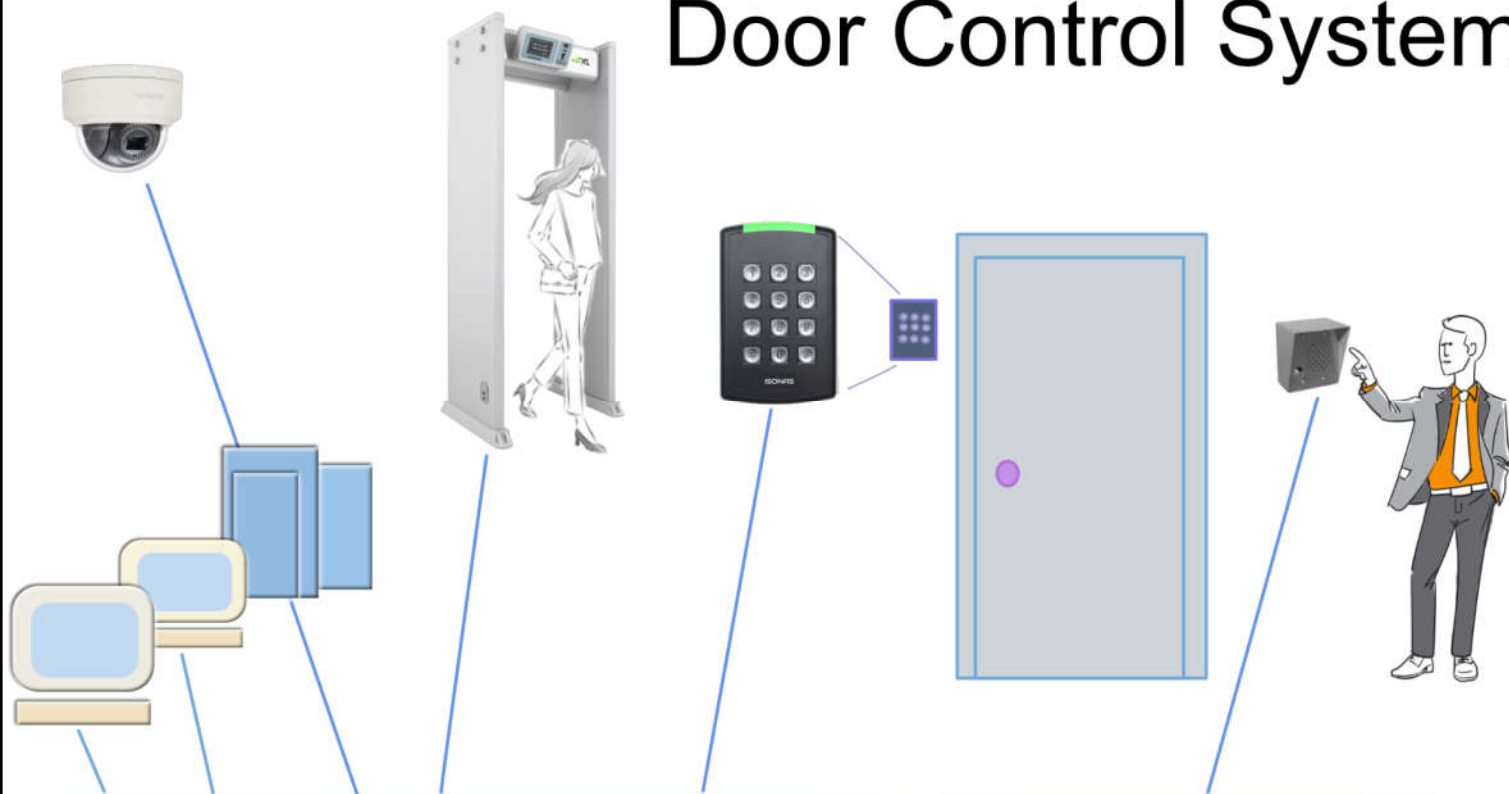
What are the key factors for door access control?

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

(Source: https://kintronics.com/comparison-security-provided-door-access-systems/)
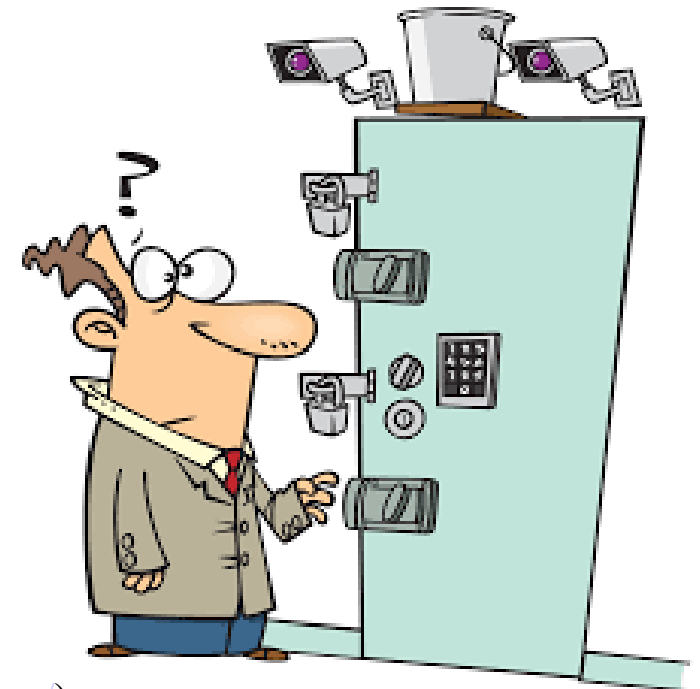
Access control system using IP controllers

Ethernet hub or switch

Host PC

To other IP controllers

Cat5 network cable

IP controller

IP controller
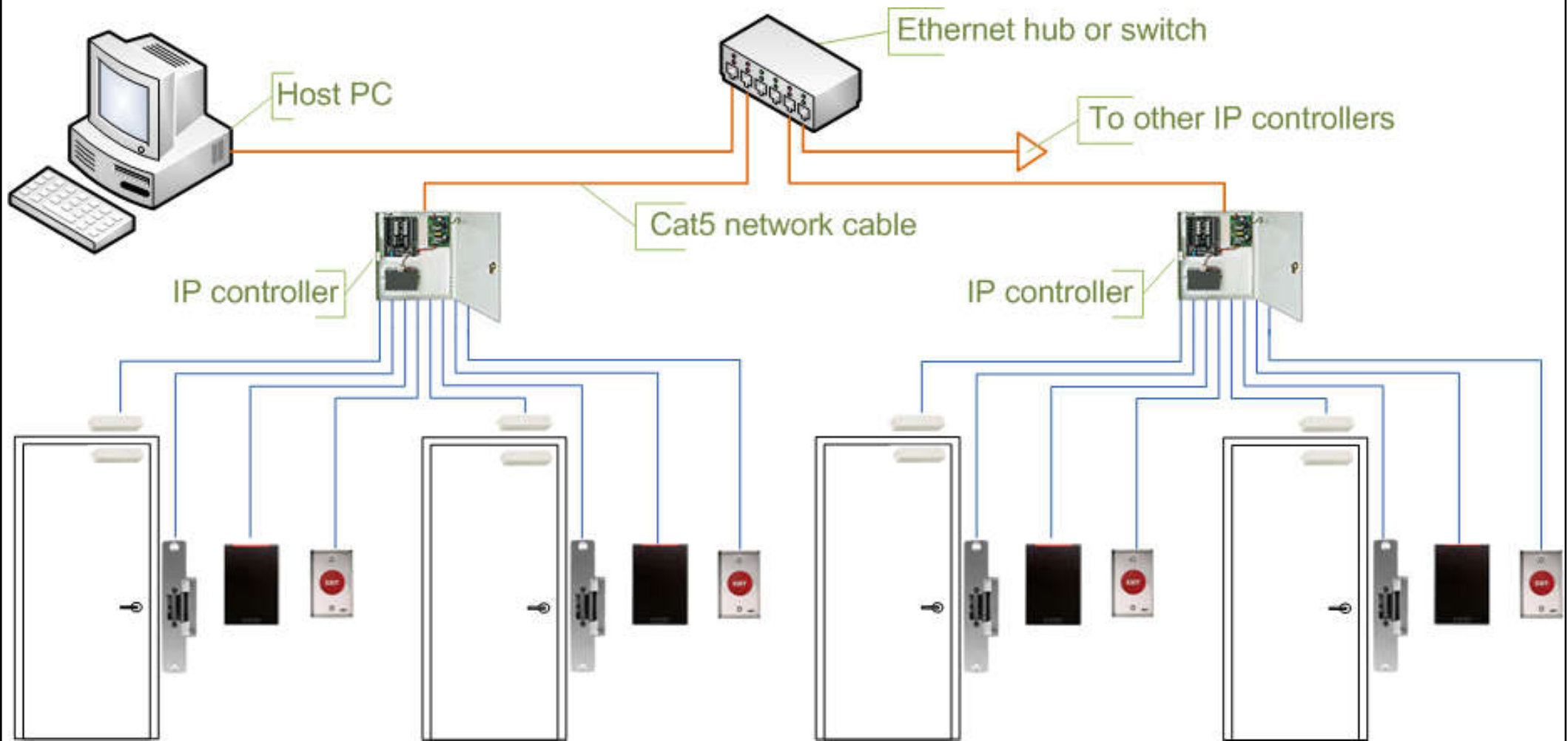
Access control

- 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)

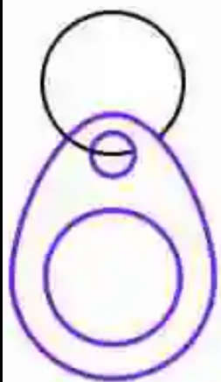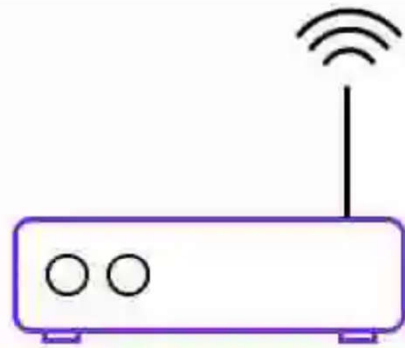# Indoor positioning system (IPS) technologies
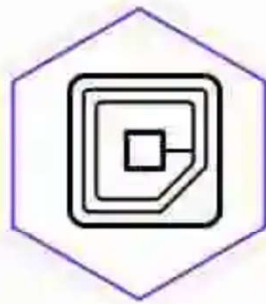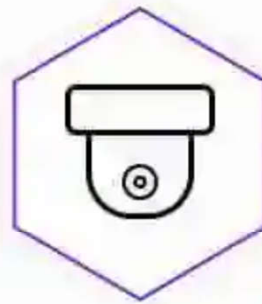
Wi-Fi UWB RFID BLE CCTV Camera GPS smartphone sensors
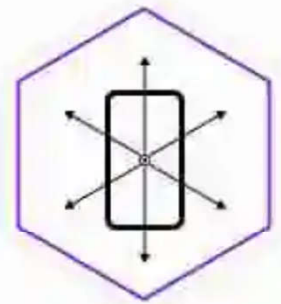
Tag — RFID BLE Wi-Fi → Proximity Reader — Tag IDs → Server → Locations Report

BLE = Bluetooth low-energy beacons
CCTV = Close-circuit television
GPS = Global positioning system
RFID = Radio frequency identification
UWB = Ultra-wideband

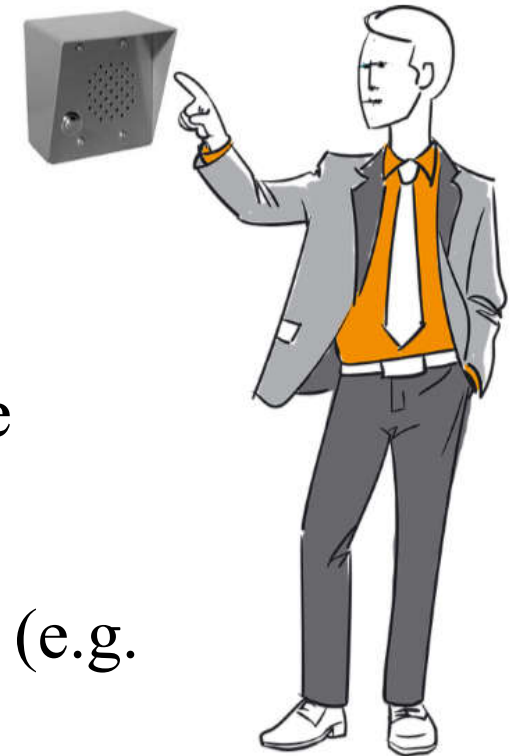# Access control

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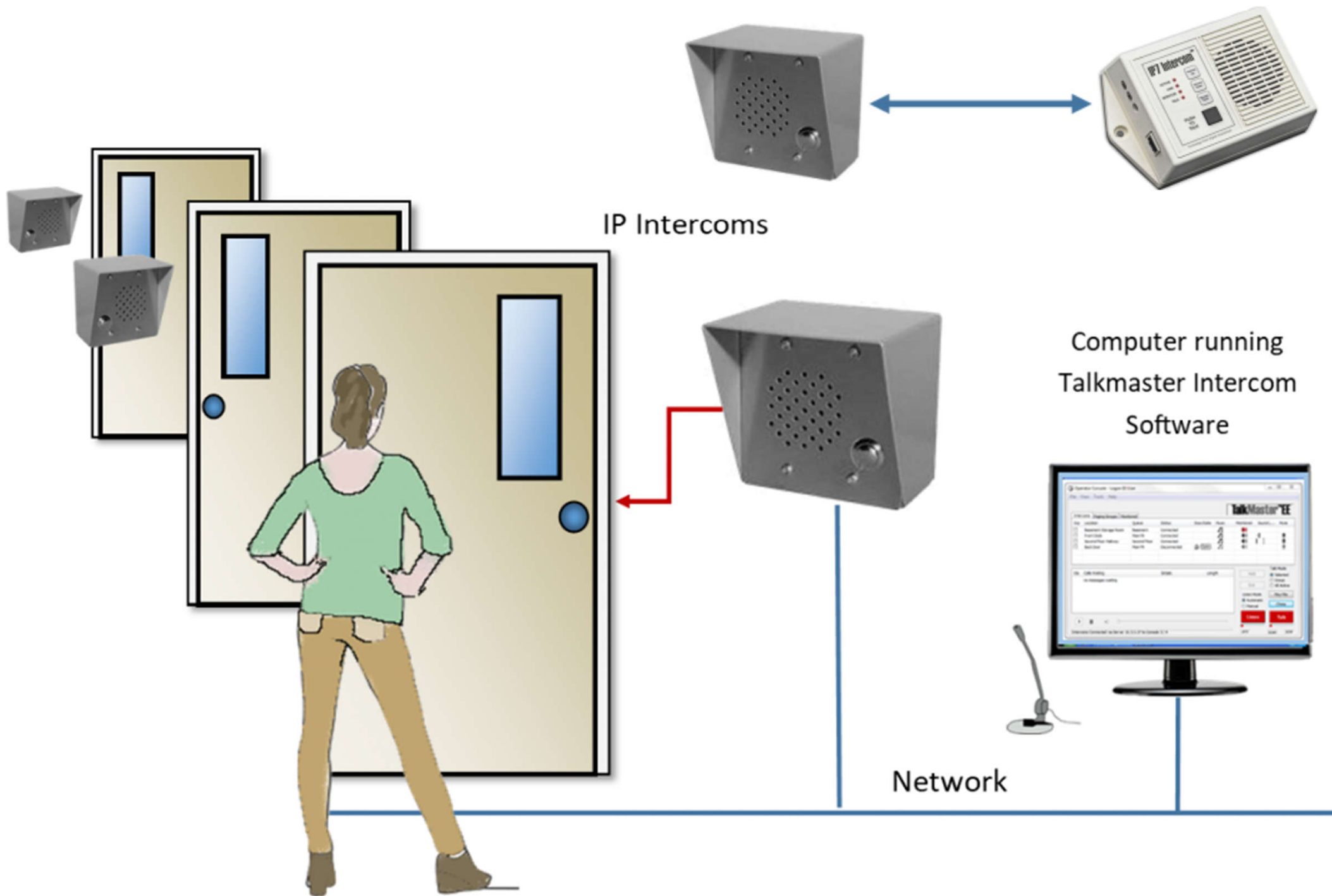 - Audio intercoms
    - One to one connections (two-way audio)
    - Many intercoms to a central control centre
  - Video intercoms
    - One intercom to one or many connections (e.g. smartphones & a central computer)
    - Integrate with IP camera systems & door access control systems to provide a complete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

Audio intercoms for door access control

IP Intercoms
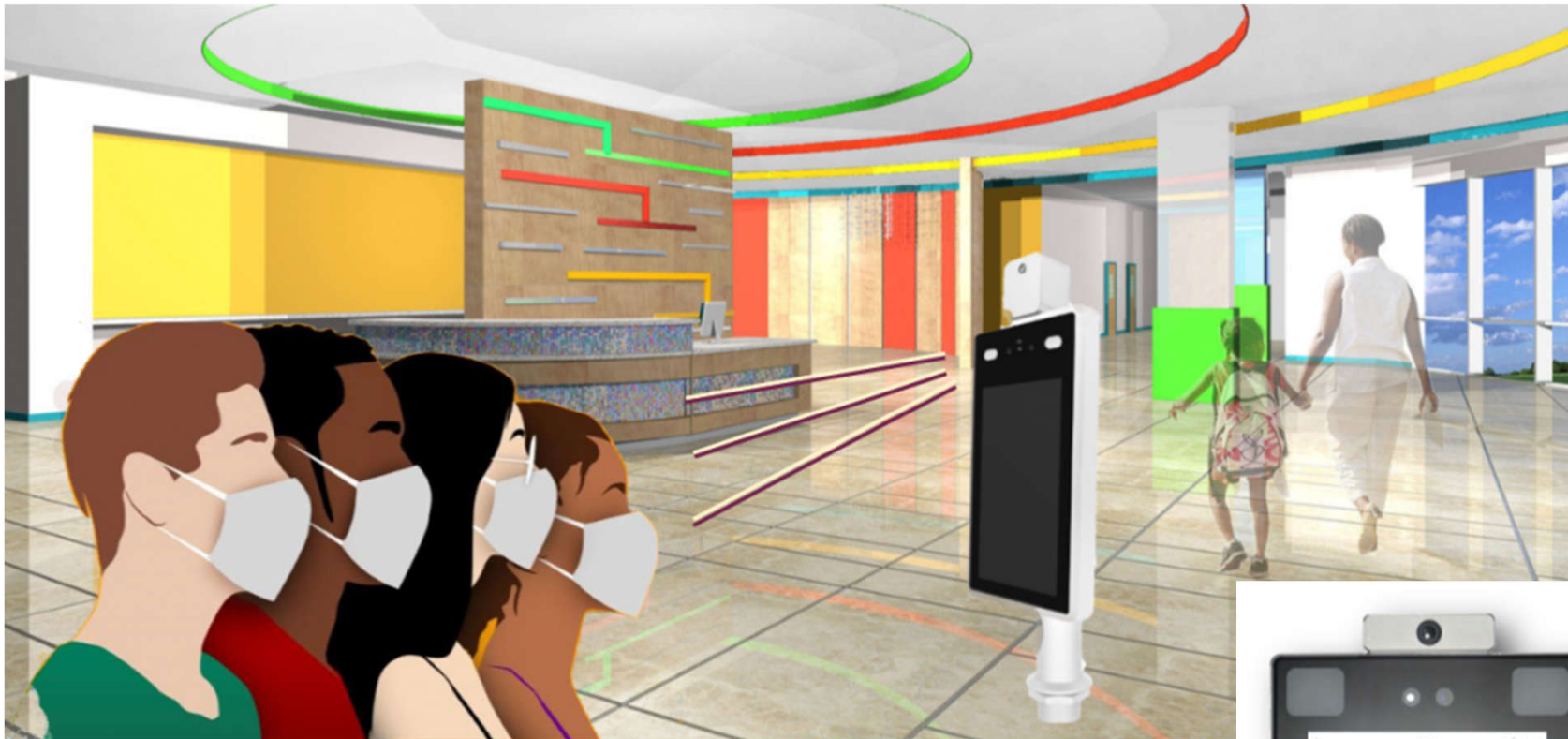
Computer running
Talkmaster Intercom
Software

Network

(Source: https://kintronics.com/ip-intercom-selection-and-comparison/)

Video intercoms & smartphone communication

(Source: https://kintronics.com/ip-intercom-selection-and-comparison/)

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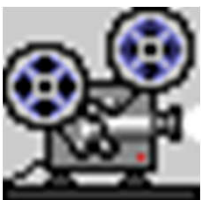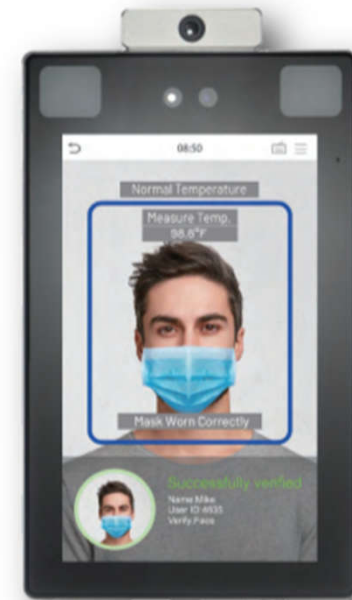
Video: Access Control with Temperature Monitoring (1:44) https://youtu.be/w49T2gpbz8Q

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
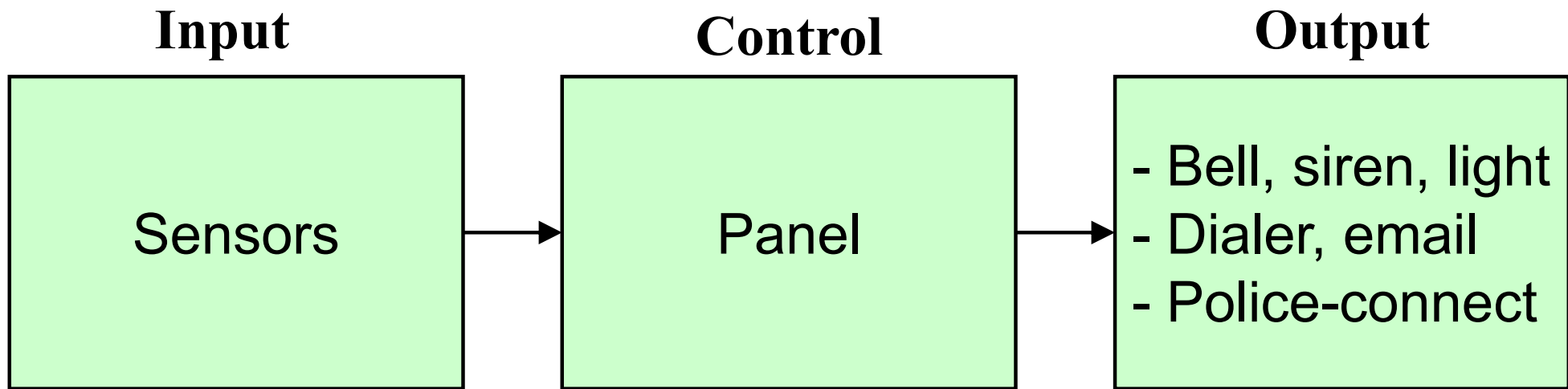
Detection sensors:
- Infrared
- Ultrasonic
- Microwave (droppler effect)
- Dual technology
- Glass breaks, switches

Annunciation/
alarm signaling

Wired Tri-technology intruder detector

Short distance wireless PIR detector

Long distance wireless PIR detector

Panic button

Magnetic contact

Smoke sensor

Heat sensor

Remote control

Beam Sensor

PSTN

Alarm receiving center

Cell phone

Telephone

Strobe light   Searchlight   High decibel horn

Typical components of a burglar alarm system

Door/Window Sensor

Remote control

Infrared detector

Wired Siren

RFID Card

Call/SMS Alarm

SOS

RFID

PIR Sensor

Smoke Sensor

Glass Break Sensor
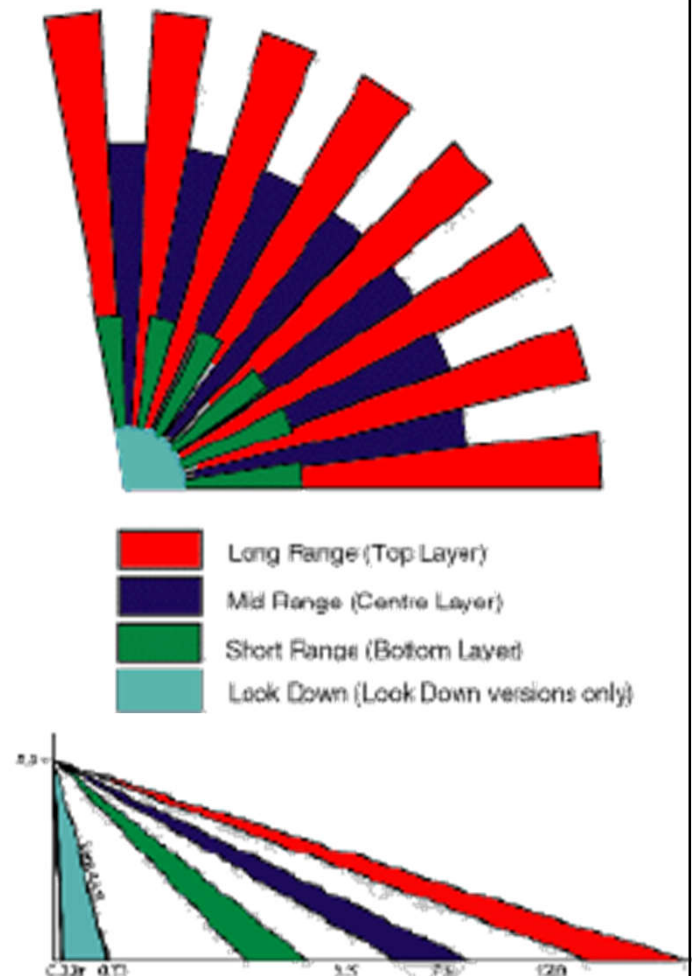
Door Sensor

Messenger

Panic Button

Buzzer

Burglar & intruder alarms
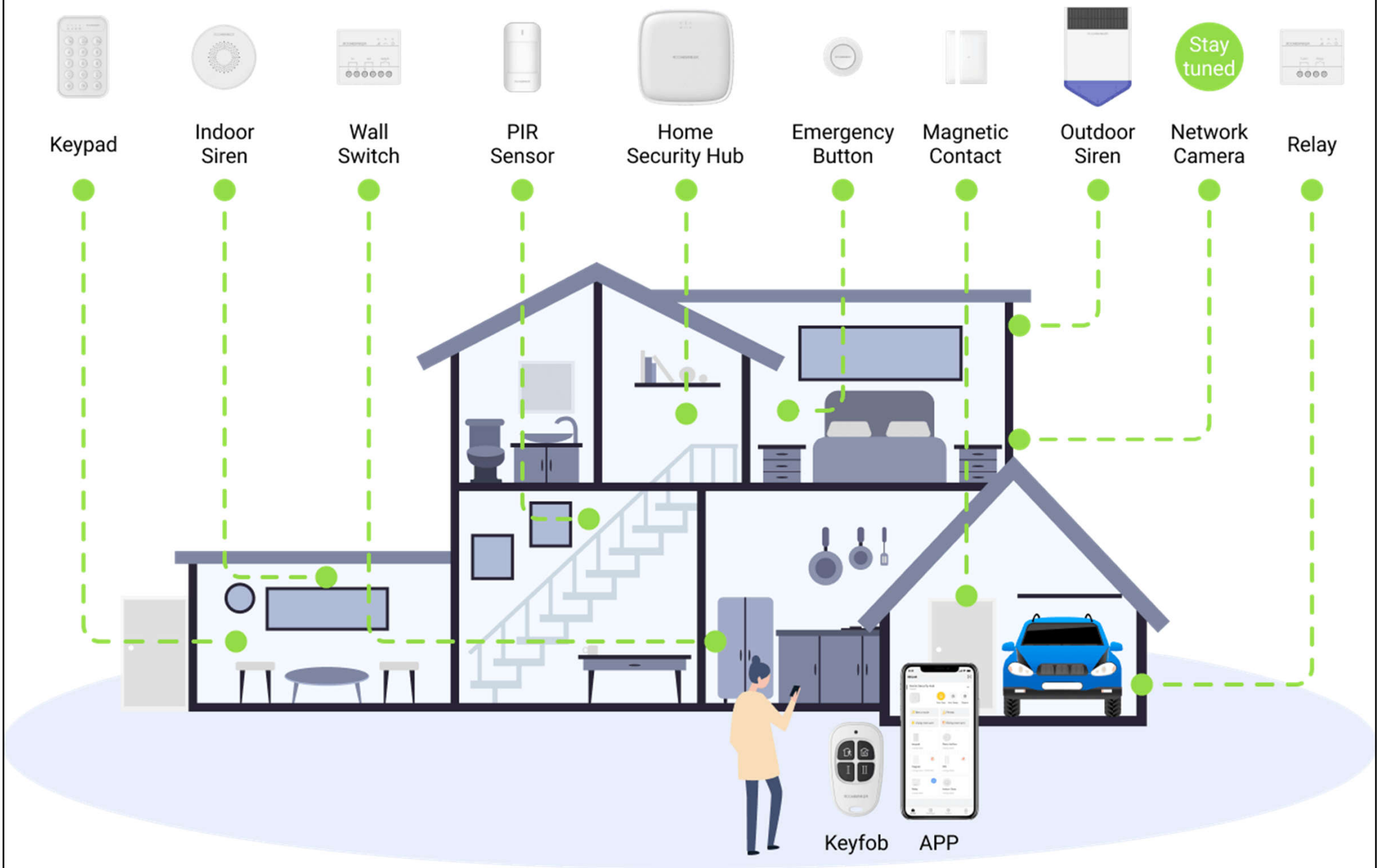
- Intruder detection alarm system
  - Mechanical contact switch
  - Magnetic contact switch
  - Glass-break & vibration detector
  - Photo-electric sensors
  - Motion sensors
    - e.g. passive infrared (PIR) sensors
  - Signaling devices
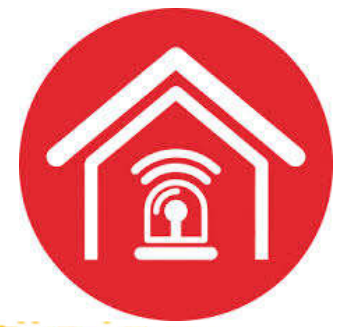   - Both audible & visual types

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 system

Keypad   Indoor Siren   Wall Switch   PIR Sensor   Home Security Hub   Emergency Button   Magnetic Contact   Outdoor Siren   Network Camera   Relay

Stay tuned

Keyfob   APP
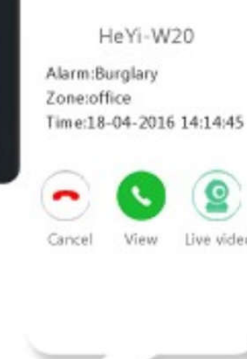
Burglar & intruder alarms

- Additional items to the basic system
  - Smoke/Gas 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
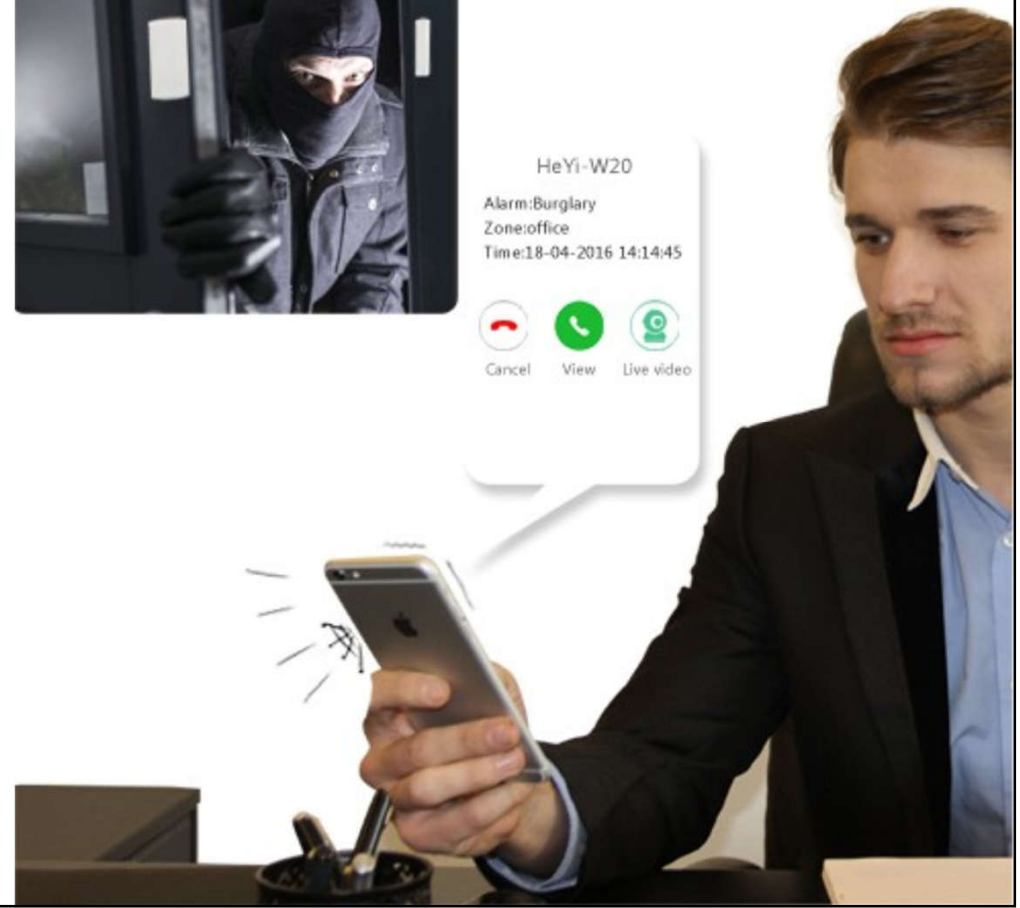
Further reading

- 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