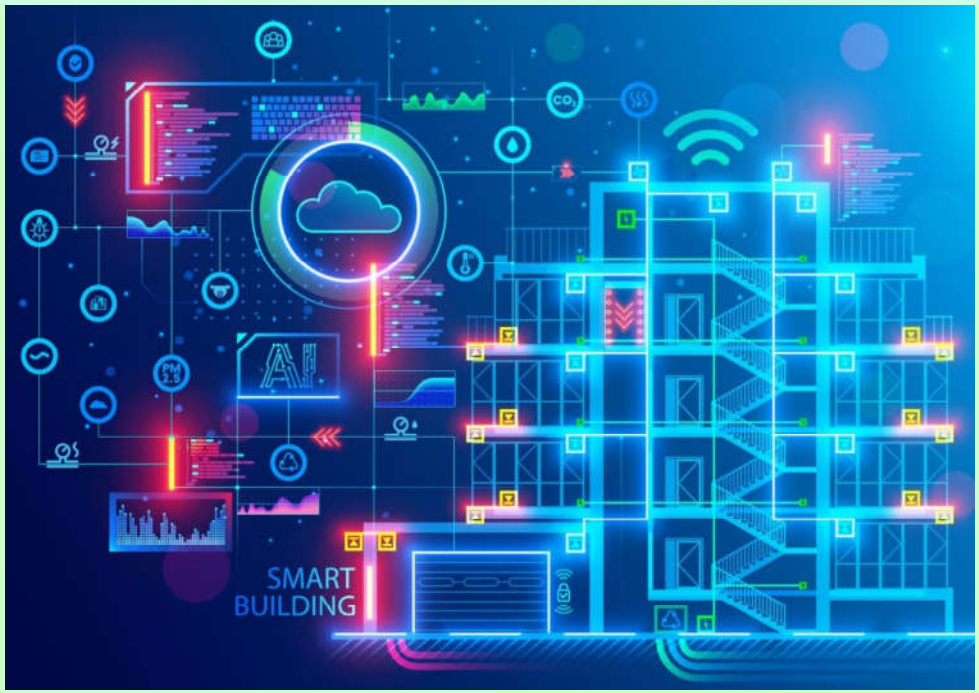
IDAT7219 Smart Building Technology

http://ibse.hk/IDAT7219/



Smart Security & Safety

智能大廈科技

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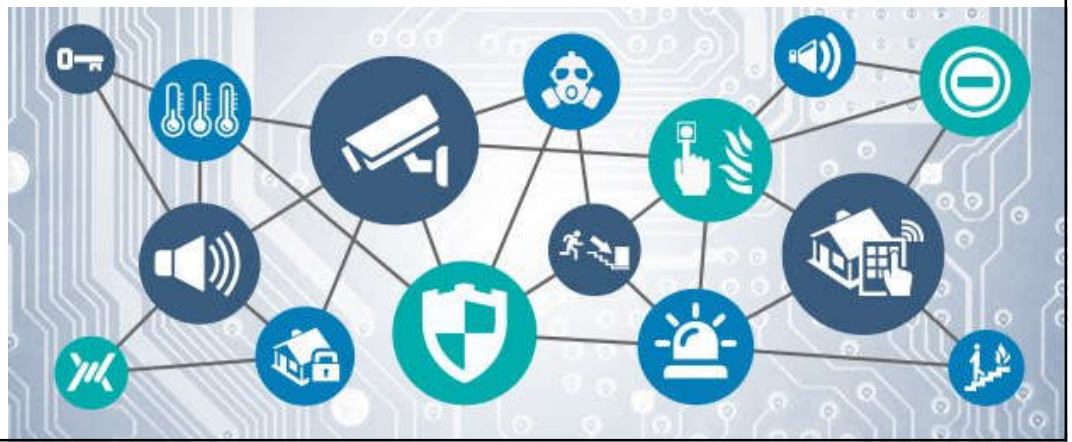
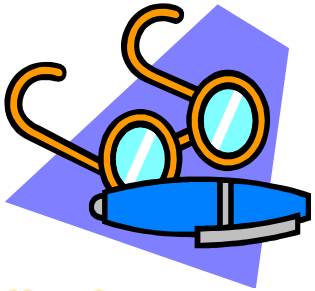
Contents

- Basic principles
- Major components
- Video surveillance
- Access control
- Burglar & intruder alarms



Basic principles

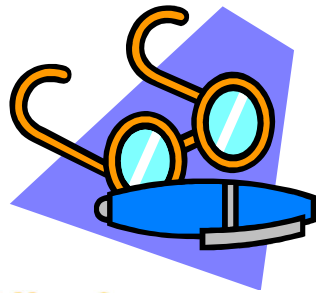


- Security & safety/protection systems
  - To guard persons & property against a broad range of hazards, including crime, fire, accidents, spying, sabotage, subversion & attack
    - Personal safety of people in the organization, e.g. employees, customers or residents
    - Tangible property, e.g. the plant, equipment, finished products, cash & securities
    - Intangible property, 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

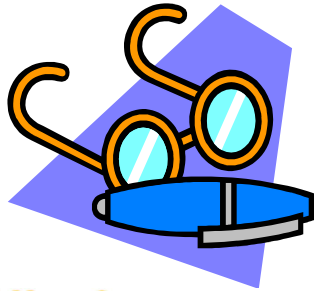
(Source: https://damiaglobalservices.com/building-energy-management-system/)

Basic principles



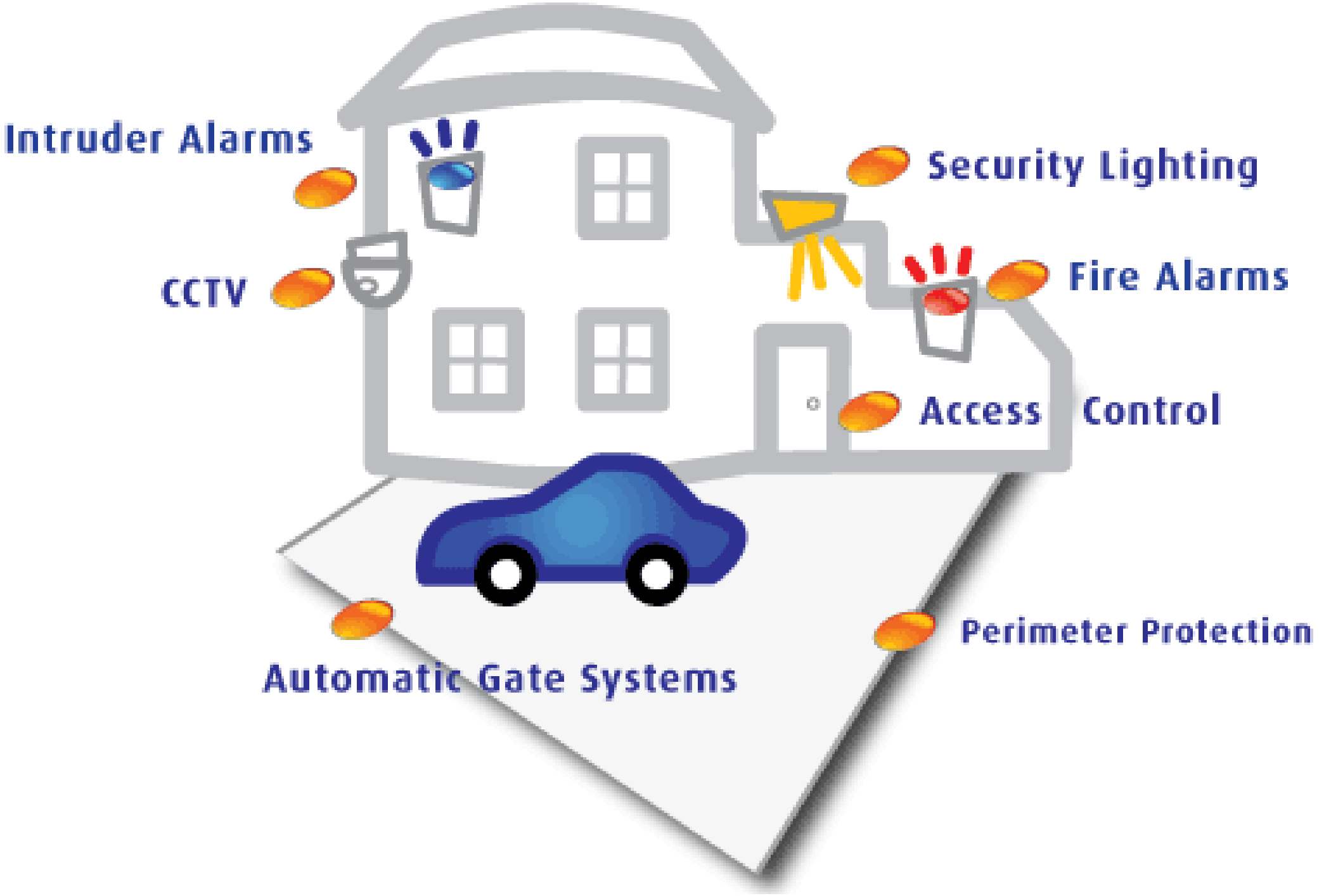
- Security systems are indispensable to any type of building. They provide consistency in business operations and keep tangible assets, intellectual property & people safe
  - Each type of property is vulnerable to different hazards and requires a unique set of safety & security measures
  - Some common building security threats: unauthorized access, fire, accidents, or other situations that pose a hazard to human life

Basic principles



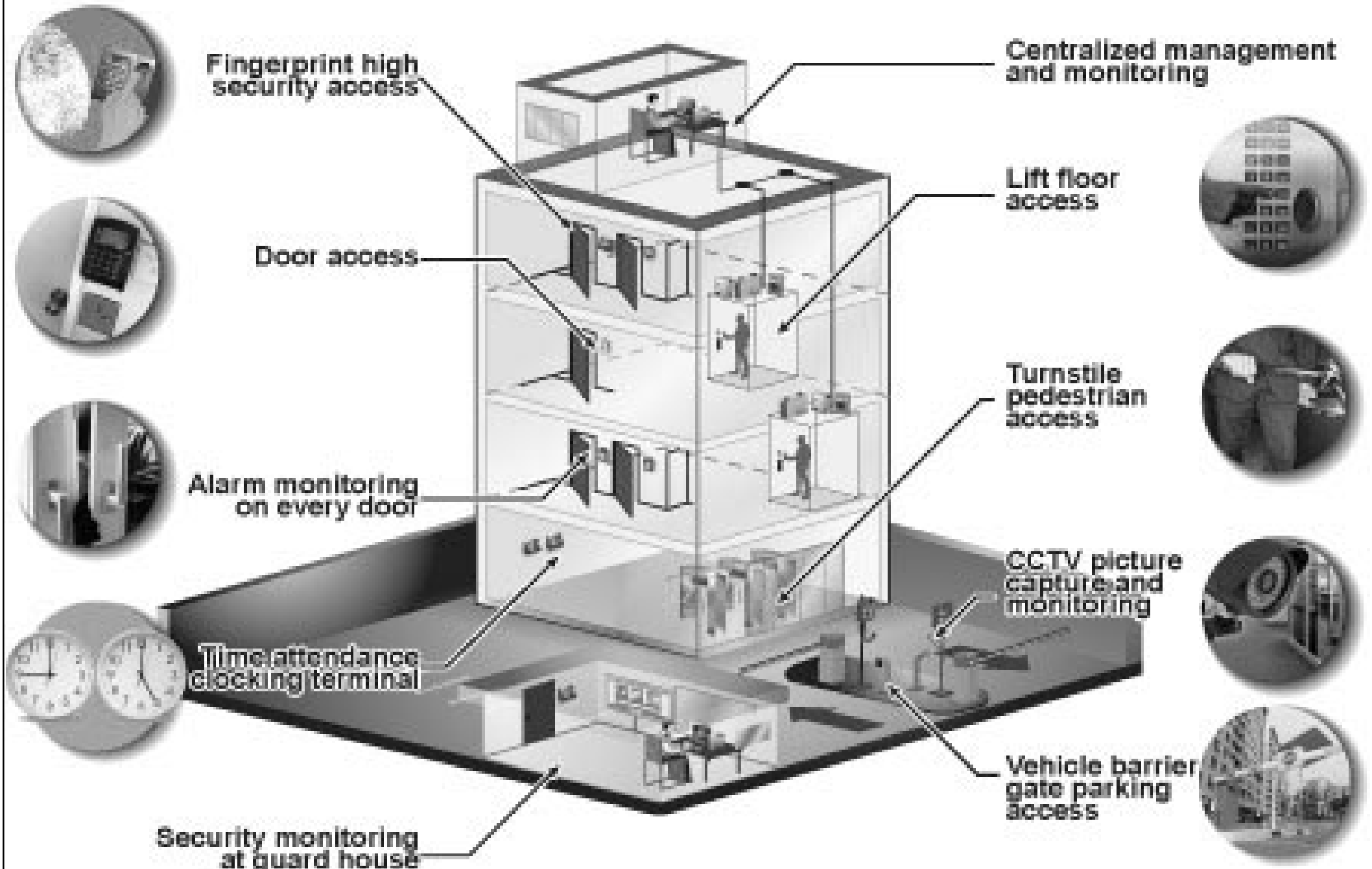
- Common types of security systems:
  - Burglar alarm system (central or local)
  - Closed circuit television (CCTV) surveillance
  - Intruder detection & access control
  - Intercom systems (audio/video)
  - Door-phone system & interlocking system
  - Panic attack (PA) button & sound system
  - Security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

Common security & alarm systems in residential buildings

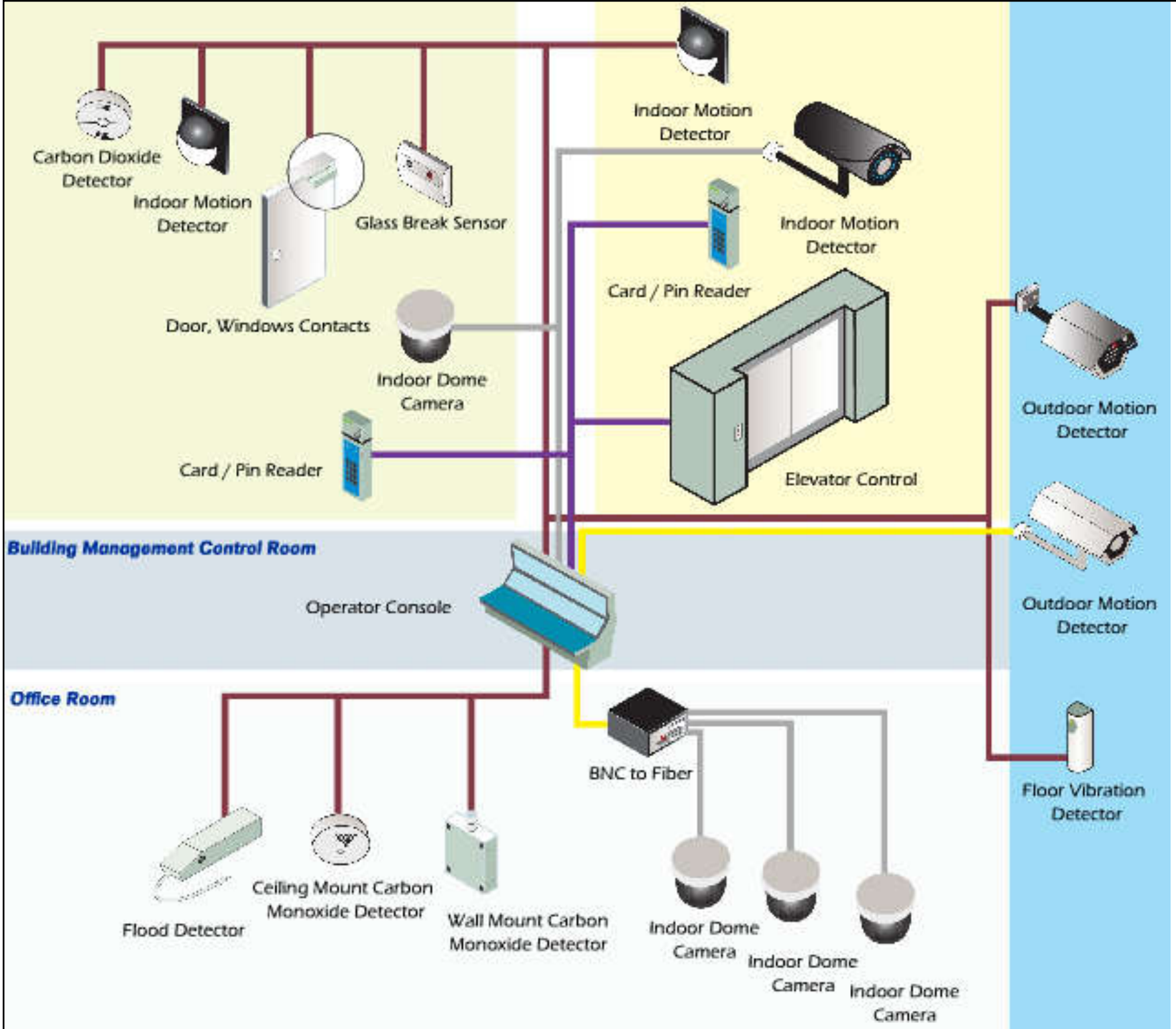


(Source: www.acesec.co.uk)

Security systems in commercial buildings



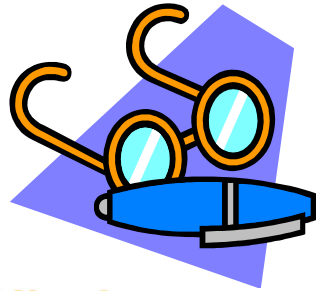
(Source: https://centricstl.com/st-louis-building-automation-systems/)



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

Functions of building automation system (BAS)

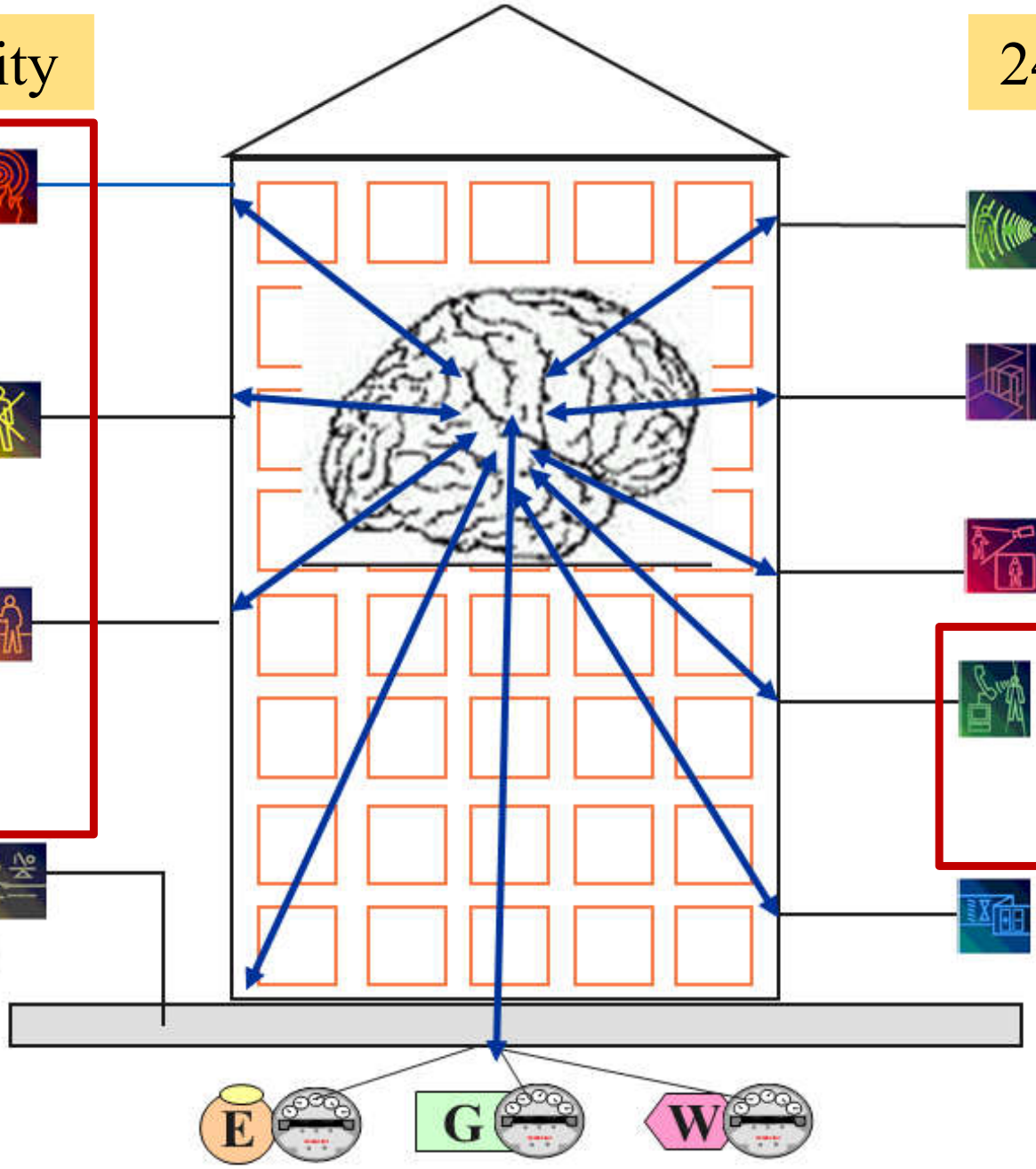
Fire & security

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



24/7 Monitoring

LIGHTING
Schedules
Occupancy Sensing

PEOPLE MOVERS
Breakdown
Maintenance
Traffic Performance

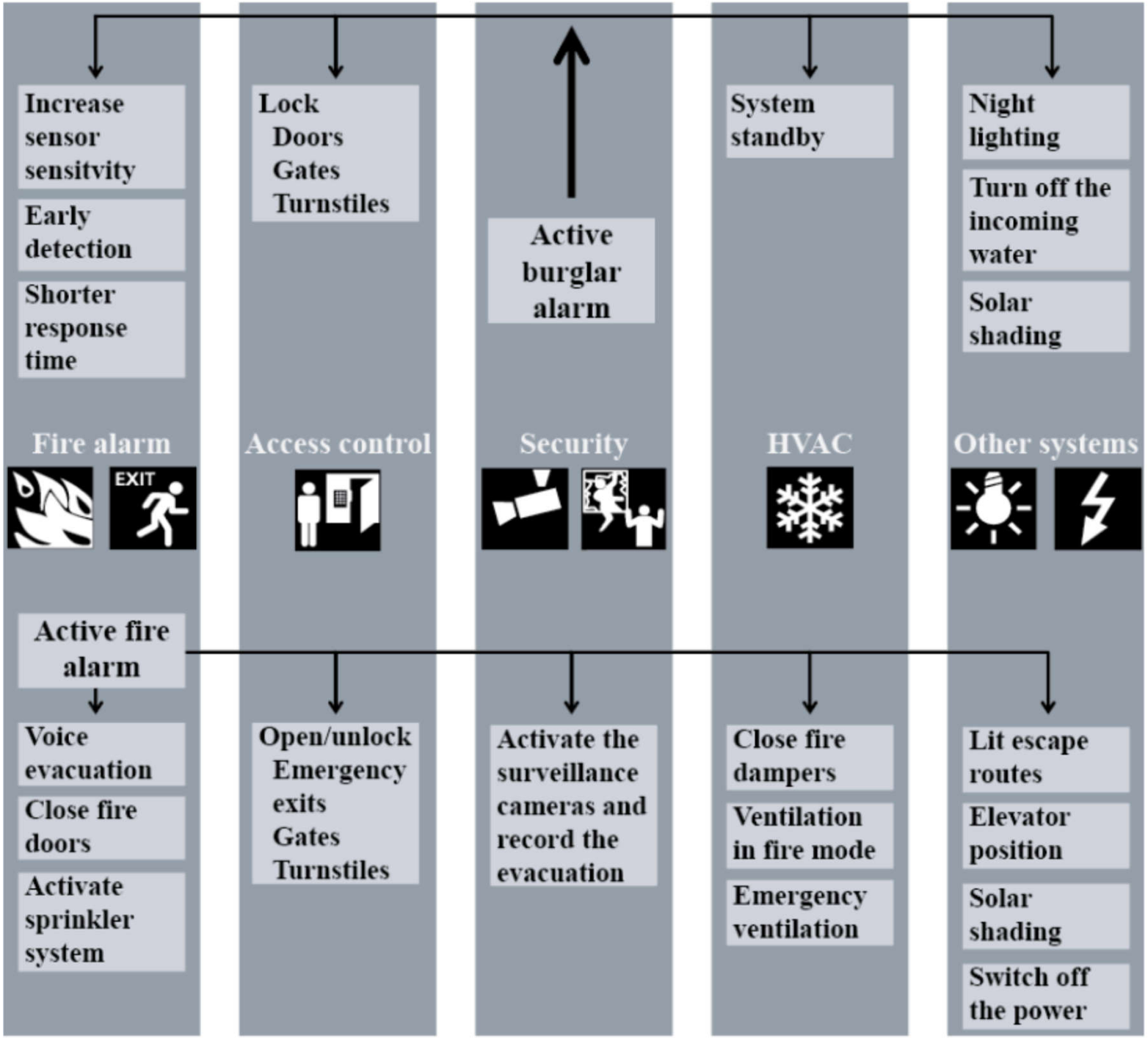
COMMUNICATIONS
Voice/Video/Data

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

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

Example of burglary & fire alarm with integrated functions in BAS



(Source: Siemens Building Technologies, Inc.)

Typical components of security & alarm systems

Intrusion Alarms

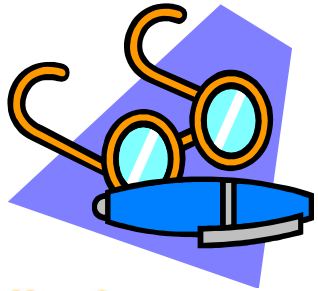
Closed Circuit Television

Digital Video Surveillance

Access Control

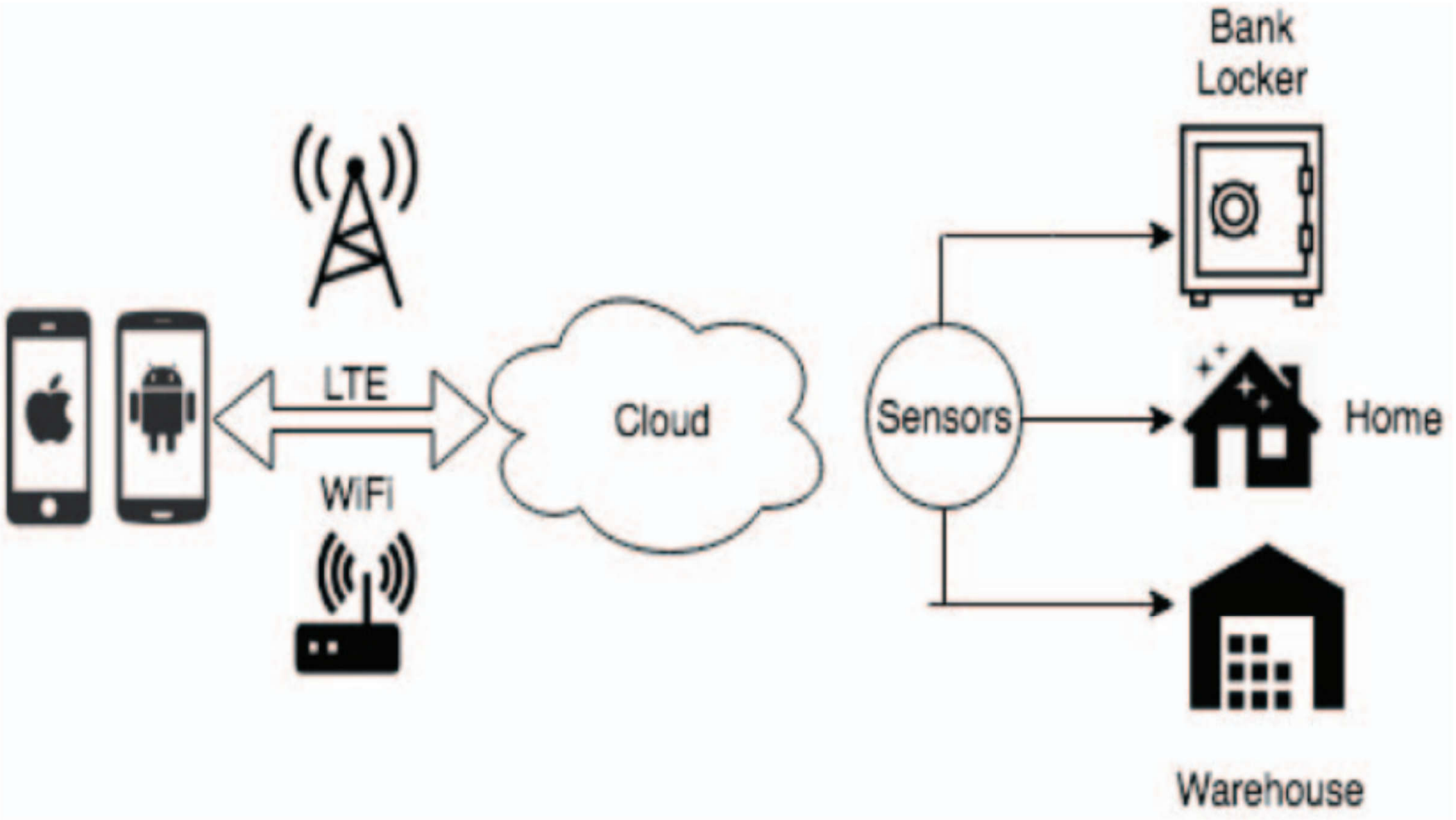
Critical Process Monitoring

Basic principles



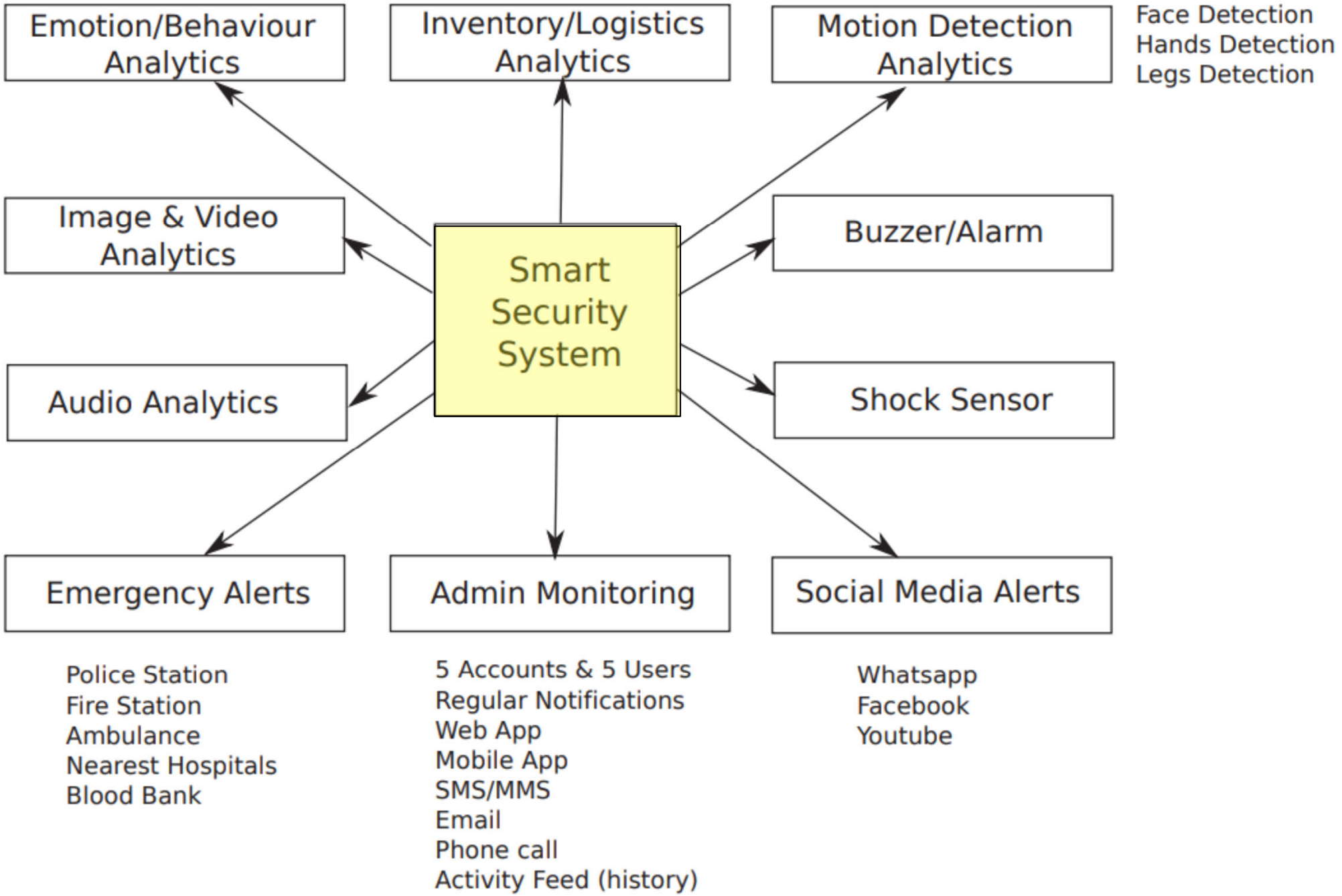
- Basic components of smart security:
  - Camera, voice sensor/microphone, motion/activity sensor, LTE/Wi-Fi module, controller
- Typical functions:
  - Simple & effective ease of installation
  - 24/7 real-time monitoring & remote control
  - Prevent & detect crime (theft, robbery or burglary)
  - Get alerts & notification in case of emergency
  - Cloud storage, analytics & reporting

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



(Source: Mahendra S., Sathiyanarayanan M. & Vasu R. B., 2018. Smart security system for businesses using Internet of Things (IoT), In *2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT)*, 16-18 August 2018, Bangalore, India, p. 424-429. http://doi.org/10.1109/ICGCIoT.2018.8753101)

Features of smart security system for homes or organisations

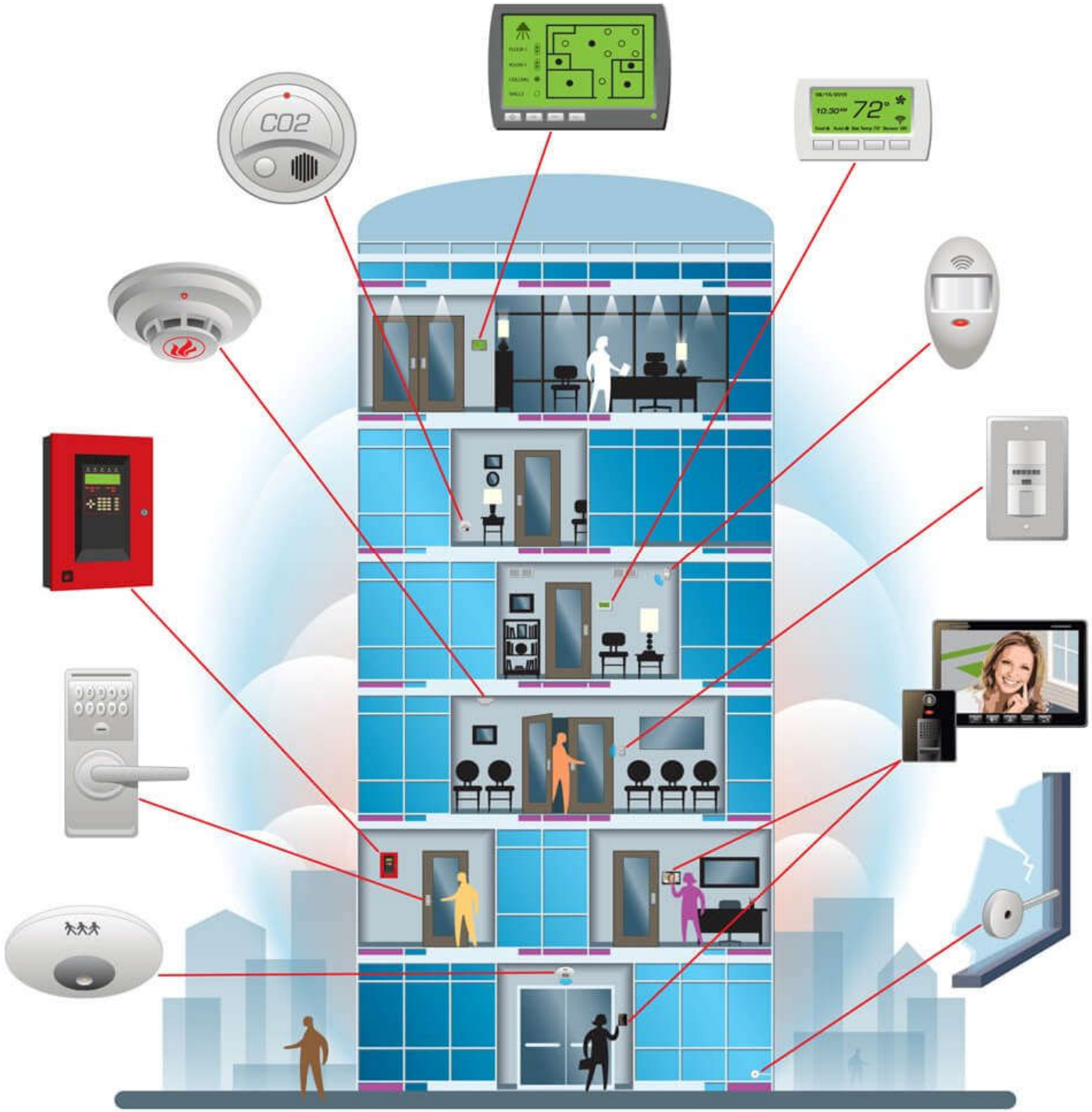


(Source: Mahendra S., Sathiyanarayanan M. & Vasu R. B., 2018. Smart security system for businesses using Internet of Things (IoT), In *2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT)*, 16-18 August 2018, Bangalore, India, p. 424-429. http://doi.org/10.1109/ICGCIoT.2018.8753101)

Major components

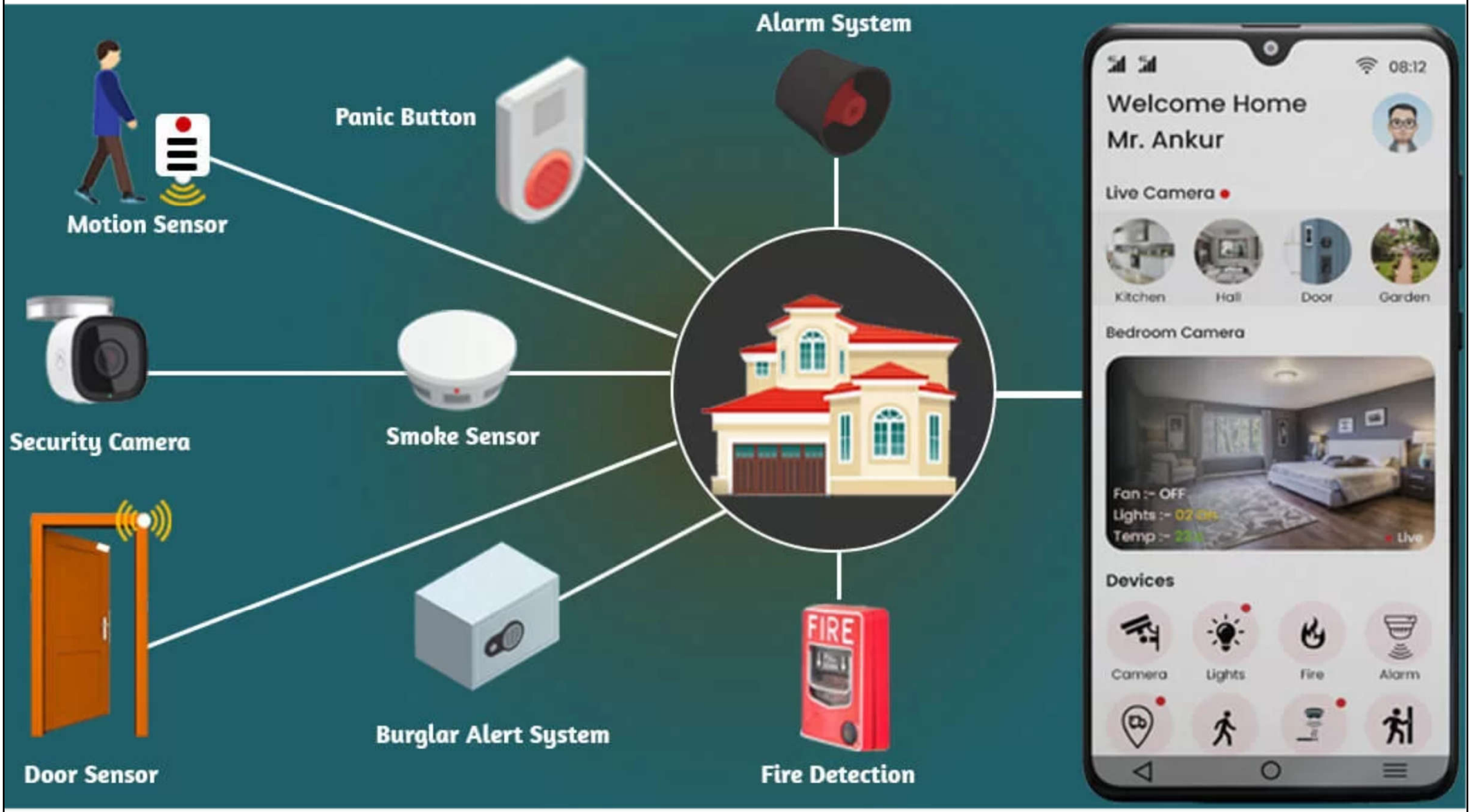
- Key components of smart security systems:
  - 1. Sensors & detectors: Detect potential security threats e.g. motion sensors, cameras & alarms
  - 2. Access control: Control who has access to certain areas or resources
  - 3. Communication & networking: Allow communication between technologies
  - 4. Monitoring & response: 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



(Source: https://damiaglobalservices.com/building-energy-management-system/)

Example of a smart home security system



(Source: https://psiborg.in/how-iot-is-used-for-home-security-and-why-it-is-required/)

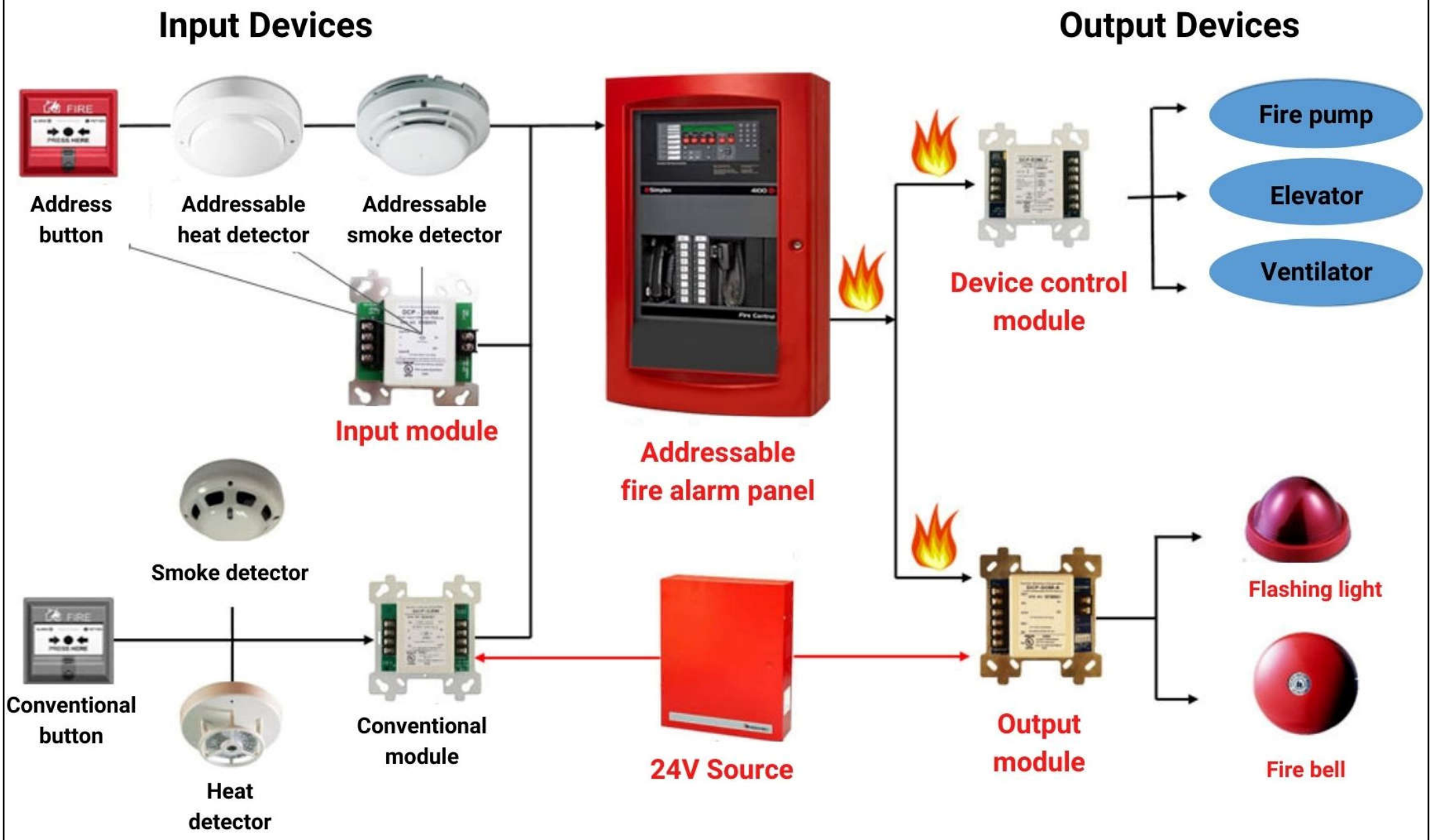
Sensors used in smart home security system

(Source: Abbas I., 2020. Efficient and robust security implementation in a smart home using the internet of things, *Indian Journal of Science and Technology*, 13 (15) 1563-1569. http://doi.org/10.17485/IJST/v13i15.9)

Major components

- BAS can control all aspects of a building, including fire alarm & security systems
- Traditional mind-set: (fear of unknown risk)
  - BAS & fire alarm systems should maintain a significant level of separation with minimal connectivity or interaction
- New thinking: (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

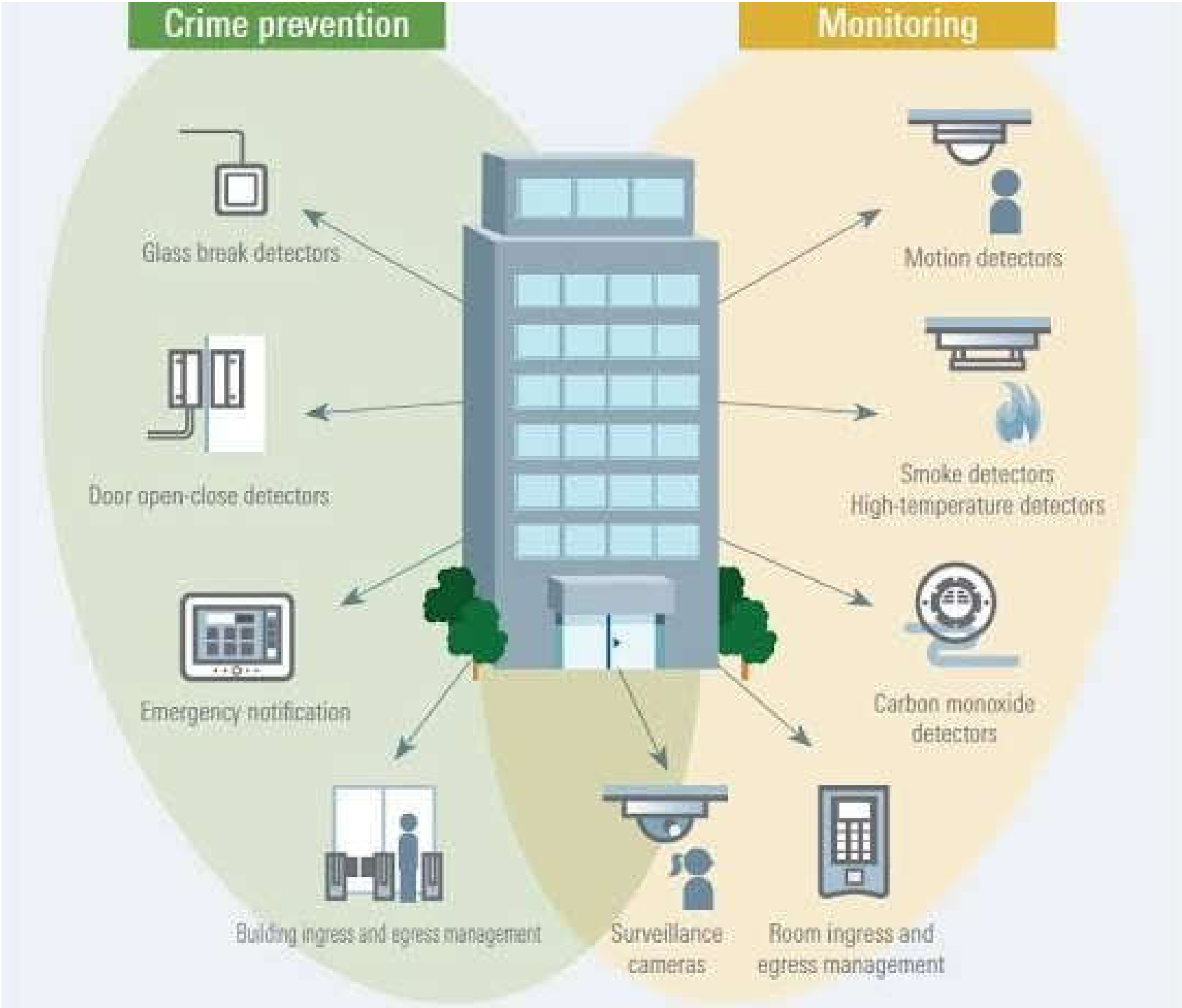


(Source: https://taisei.com.vn/automatic-fire-alarm-system-for-building)

Major components

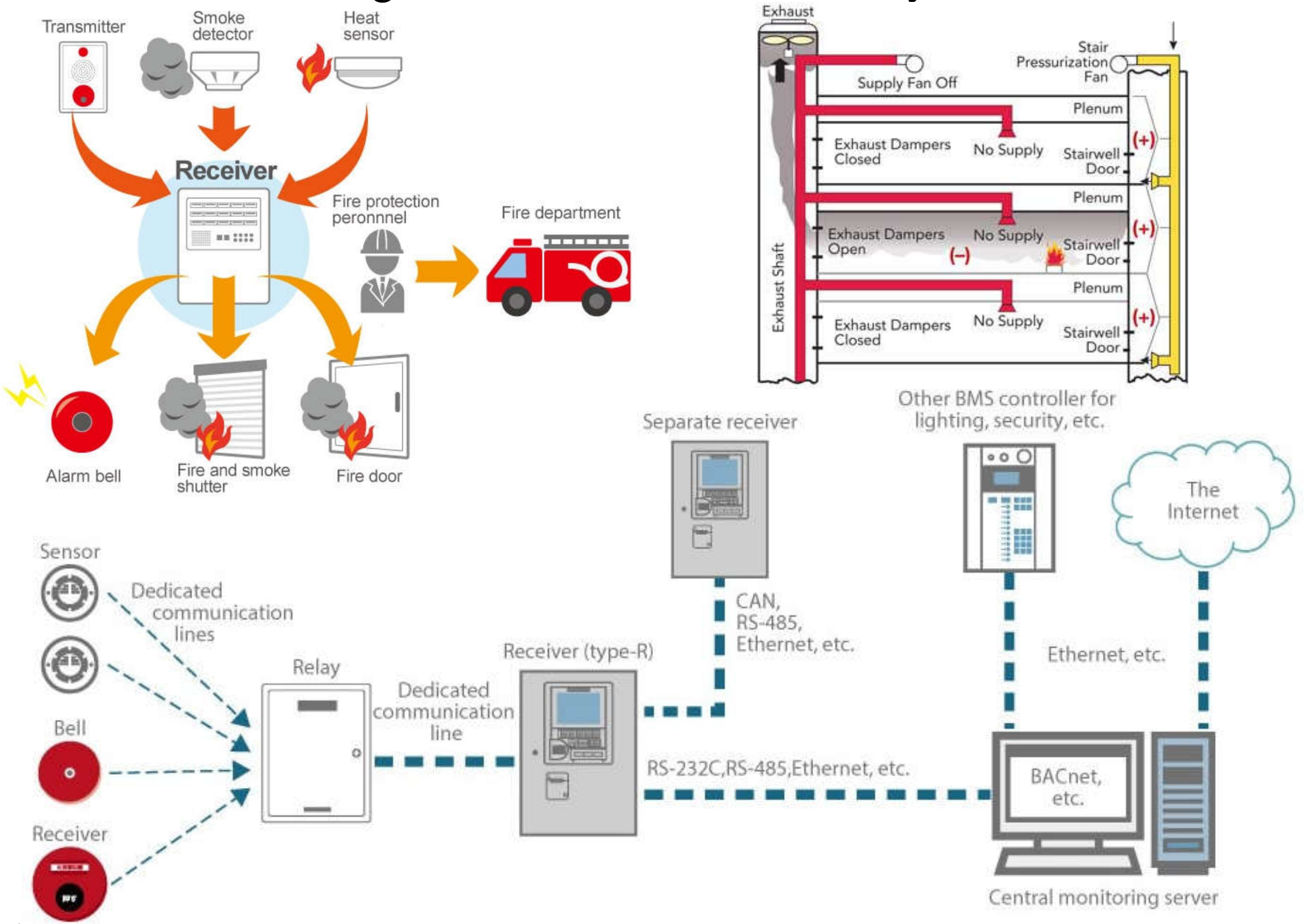
- BAS are sometimes linked to fire alarm systems, access control, other security systems & elevator/lift control for monitoring
  - In case a fire is detected then only the fire alarm panel could close dampers in the ventilation system to stop smoke spreading, shut down air handlers, start smoke evacuation 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/)

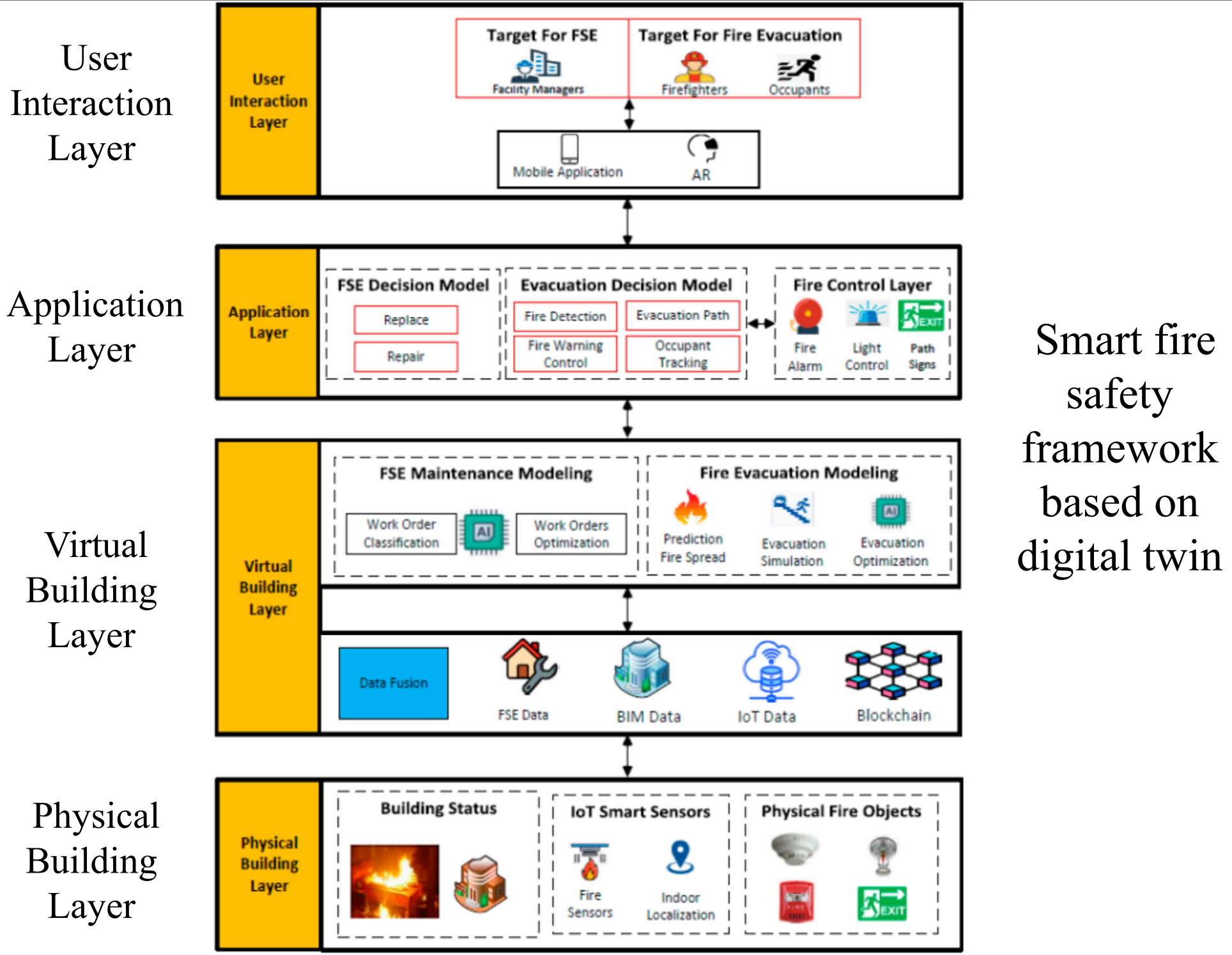
Integration of BAS & fire alarm systems



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

Major components

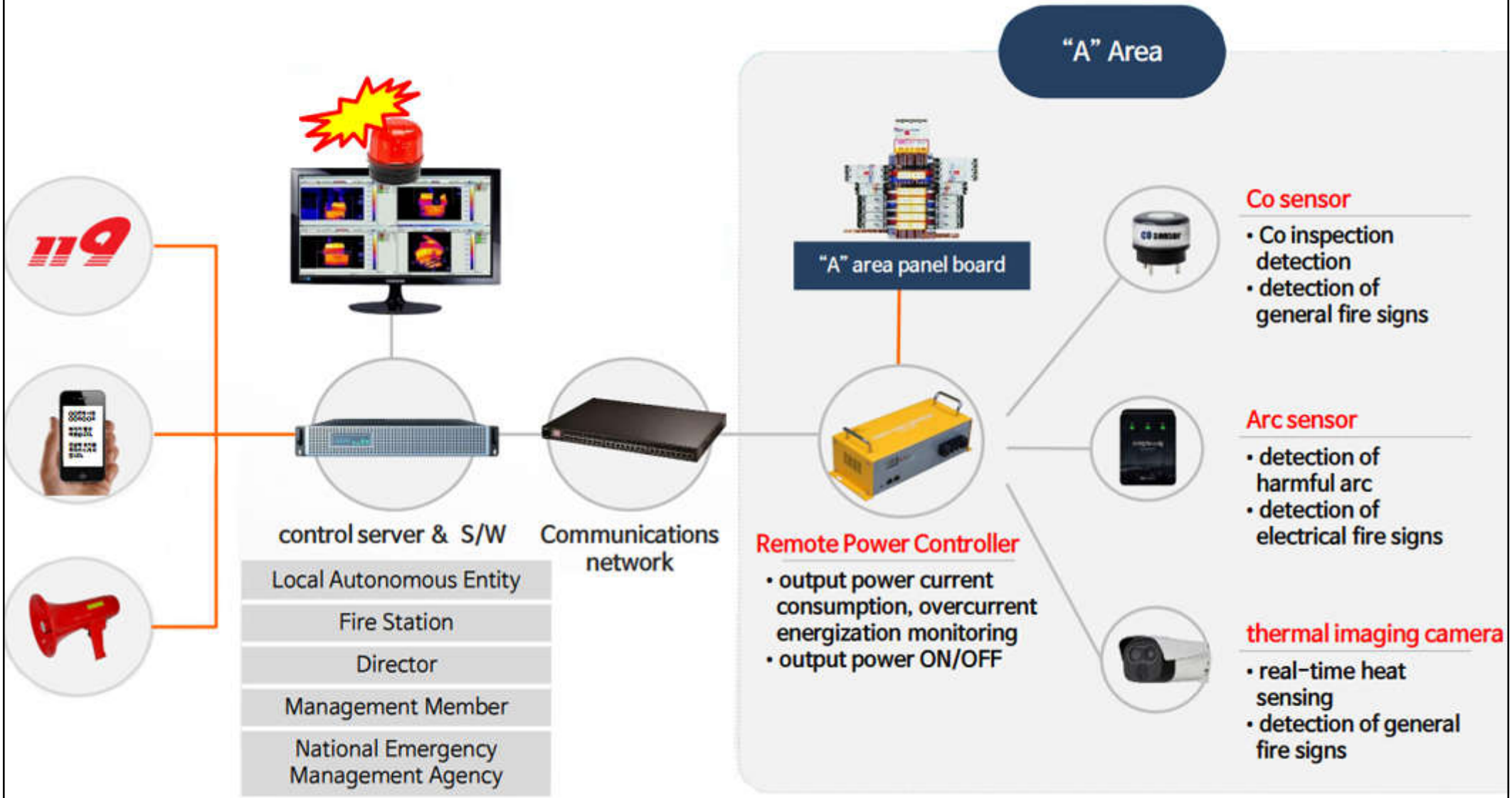
- Smart fire alarm systems
  - All the components (fire alarms, smoke detectors, sprinkler system etc.) can ‘talk’ & communicate with each other
  - Various automations can be made to improve the safety of individuals & the site
  - Faults can be detected & alarm activity is captured
  - All the data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



Smart fire safety framework based on digital twin

(Source: Almatared M., Liu H., Abudayyeh O., Hakim O. & Sulaiman M., 2024. Digital-twin-based fire safety management framework for smart buildings, *Buildings*, 14 (1) 4. https://doi.org/10.3390/buildings14010004)

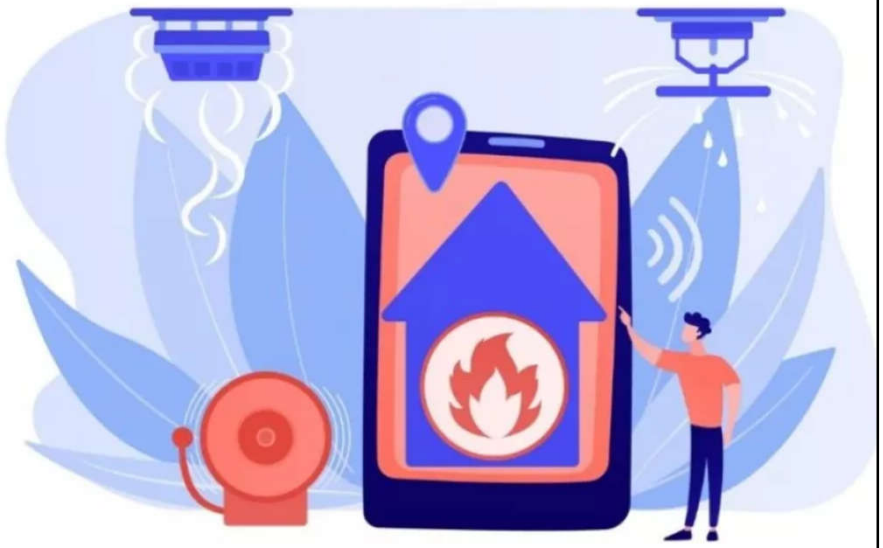
Basic concept of a smart fire alarm & detection system



(Source: http://www.cw-tpm.com/en/business-field/cooperation-division/smart-fire-detection-system/)

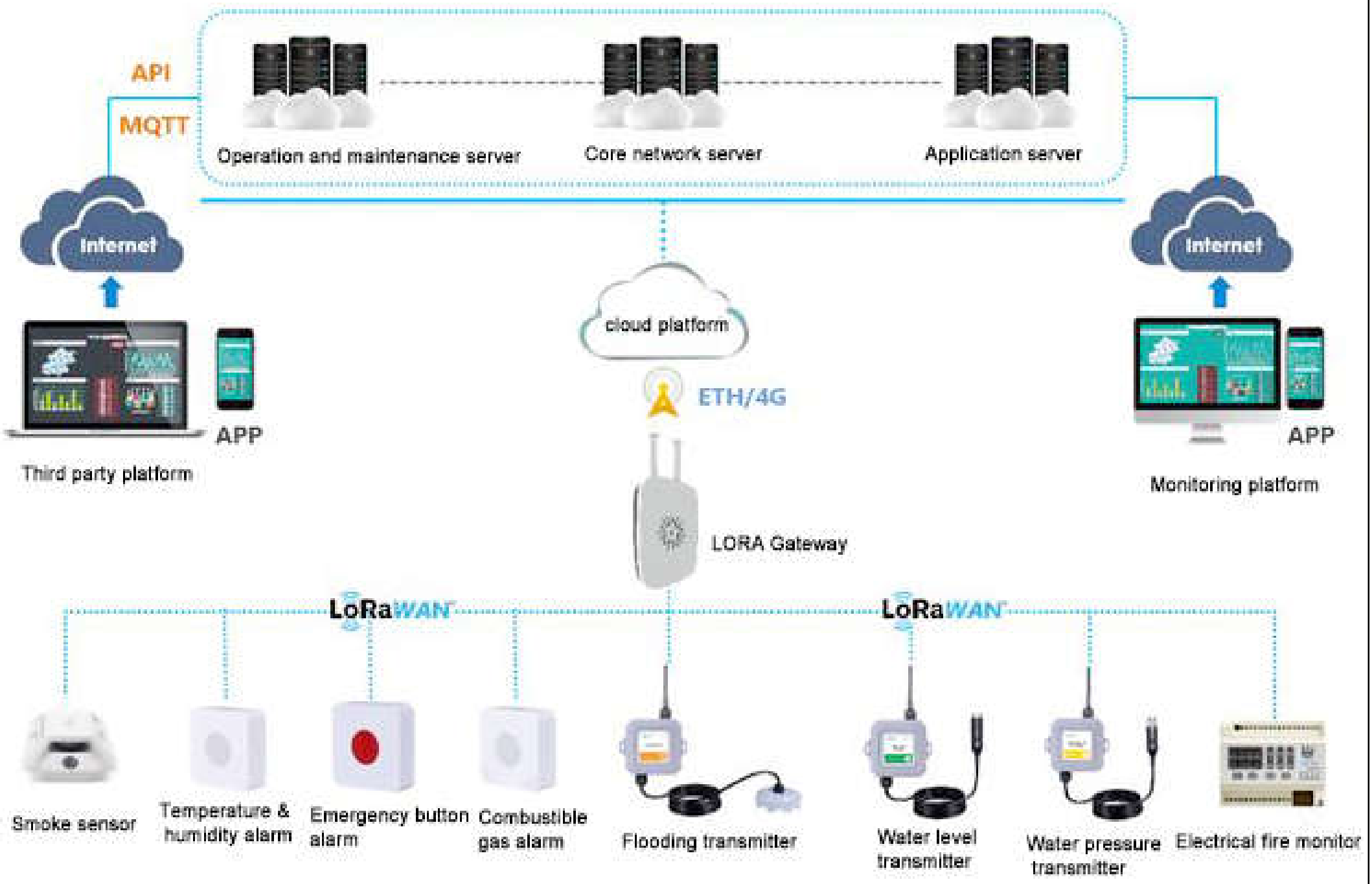
Major components

- 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



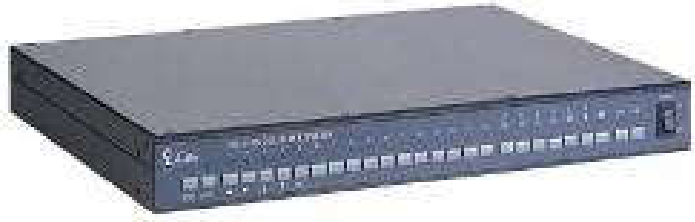
(Source: https://cdsentec.com/what-is-smart-fire-protection/)

Example of fire panel operations in a smart fire protection system

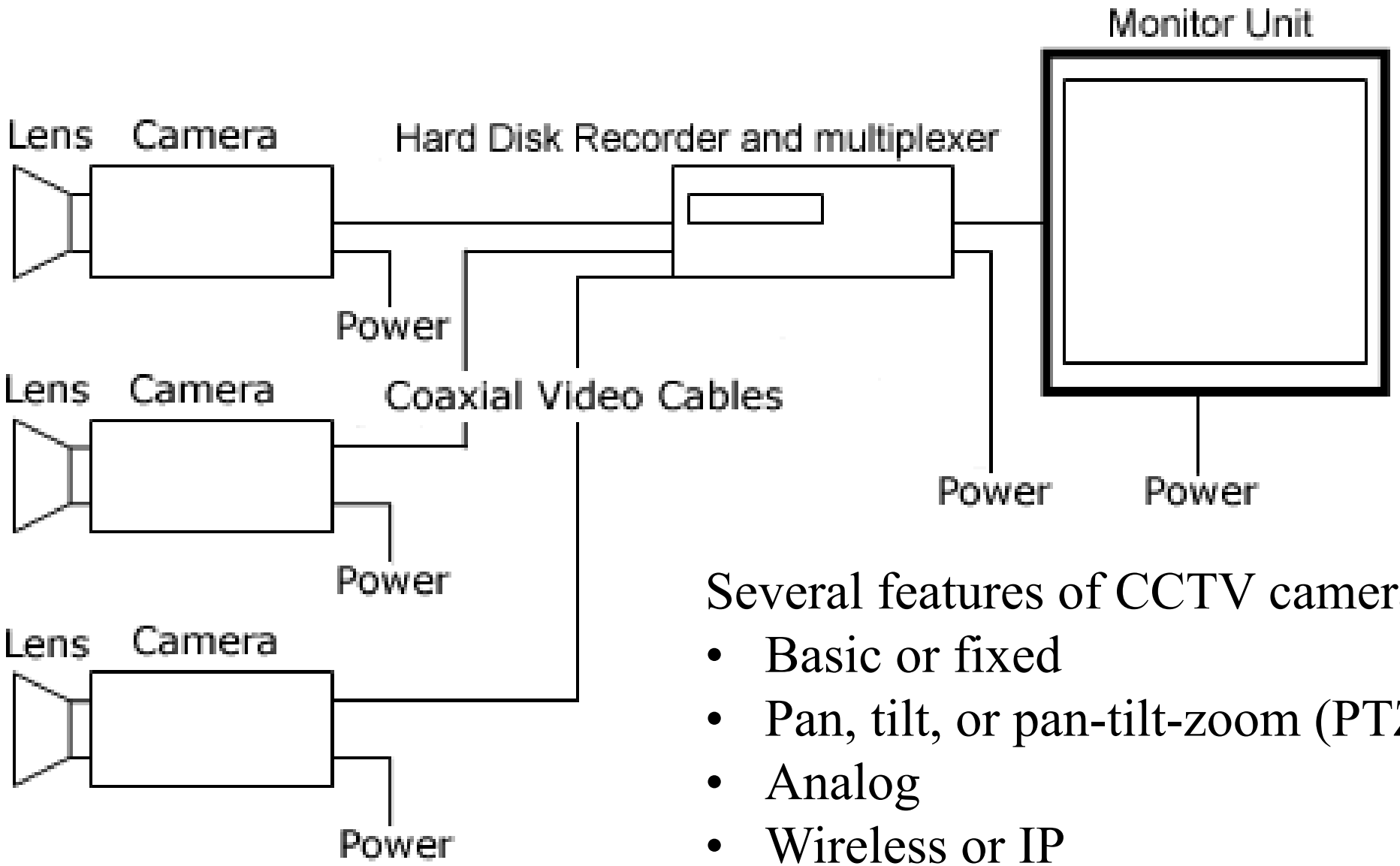
(Source: https://www.greenestbuilding.com/smart-building/fire-alarm-system/)

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



Several features of CCTV cameras:

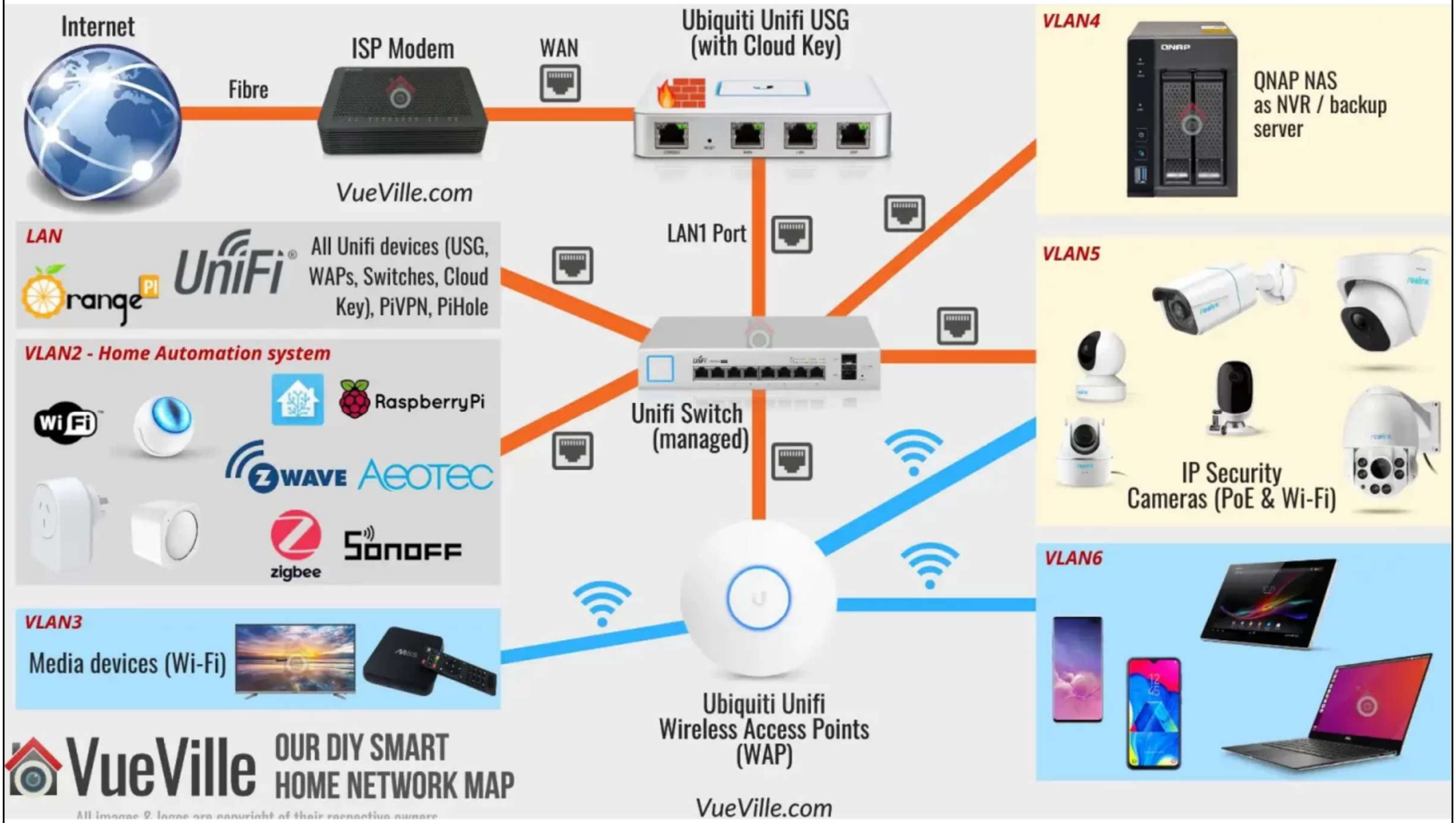
- Basic or fixed
- Pan, tilt, or pan-tilt-zoom (PTZ)
- Analog
- Wireless or IP
- Night vision
- Exterior
- Motion-detection

(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



(Source: https://www.vueville.com/blog/how-we-built-our-diy-home-security-camera-system/)

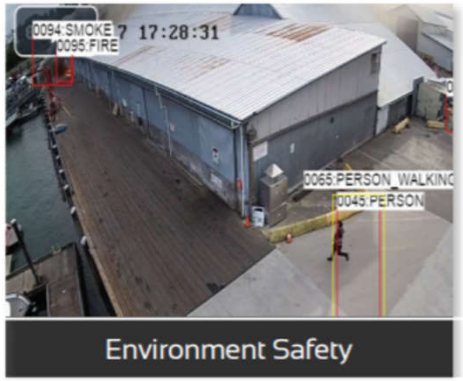
Video surveillance

- 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)

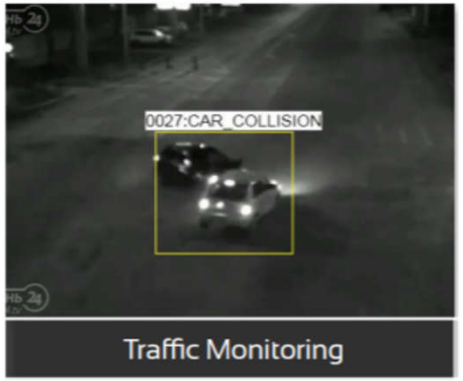
CCTV smart cameras for image recognition

Behavioral recognition by using CCTV video content analysis

Violent Activity Recognition



Environment Safety



Traffic Monitoring

Violent Activity • People fighting • Brawl/Riot • Vandalism • Person with blood • Person with weapon	**Suspicious Activity** • Contextual loitering, tailgating • Person abandons an object • Person with mask /no mask • Person running/walking/falling • Person gets in/out of a vehicle	**Person & Crowd Behaviour** • 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

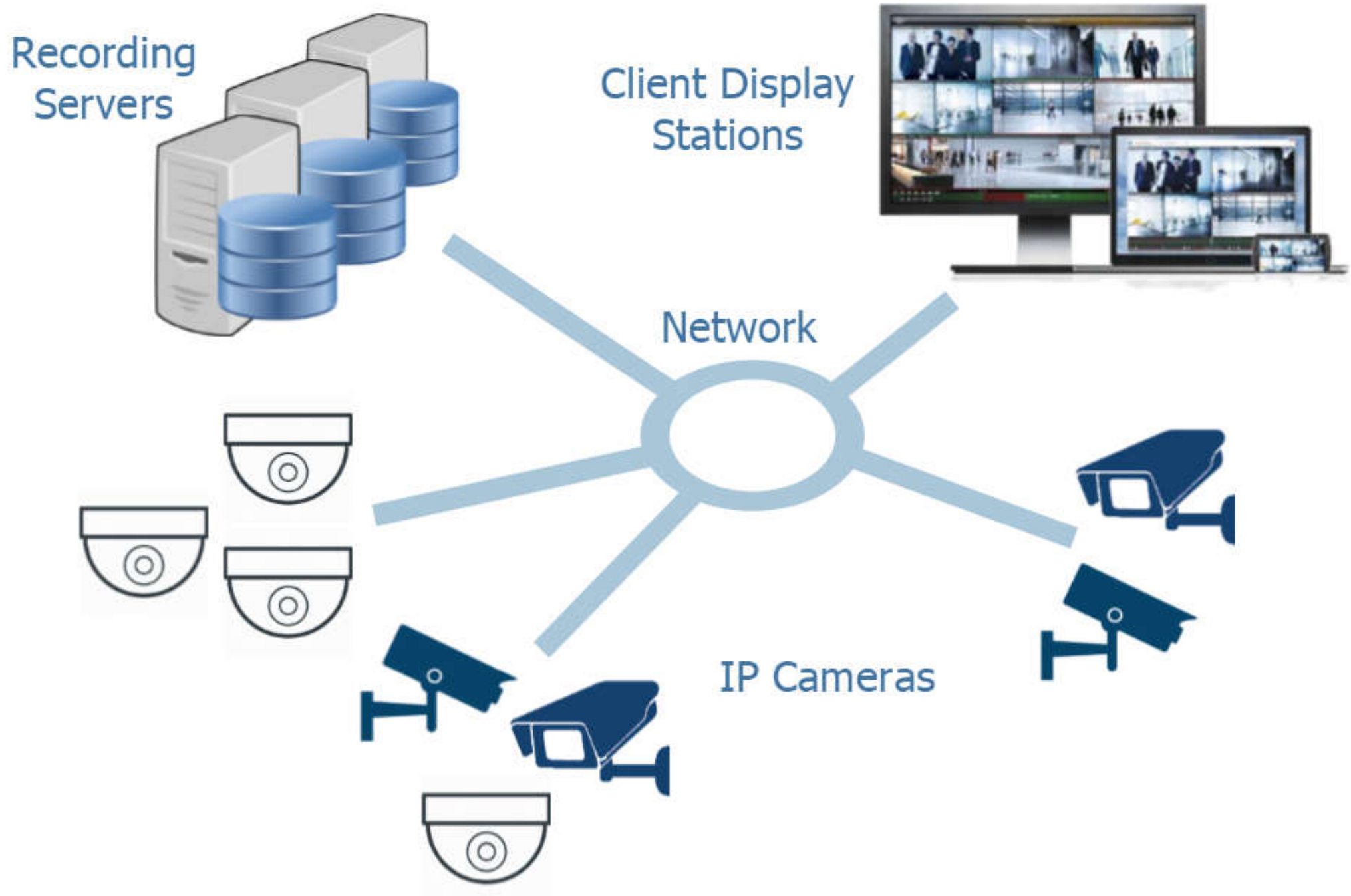
Video: Understanding for security and surveillance (3:04)
https://www.viisights.com/products/wise/

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

Video surveillance

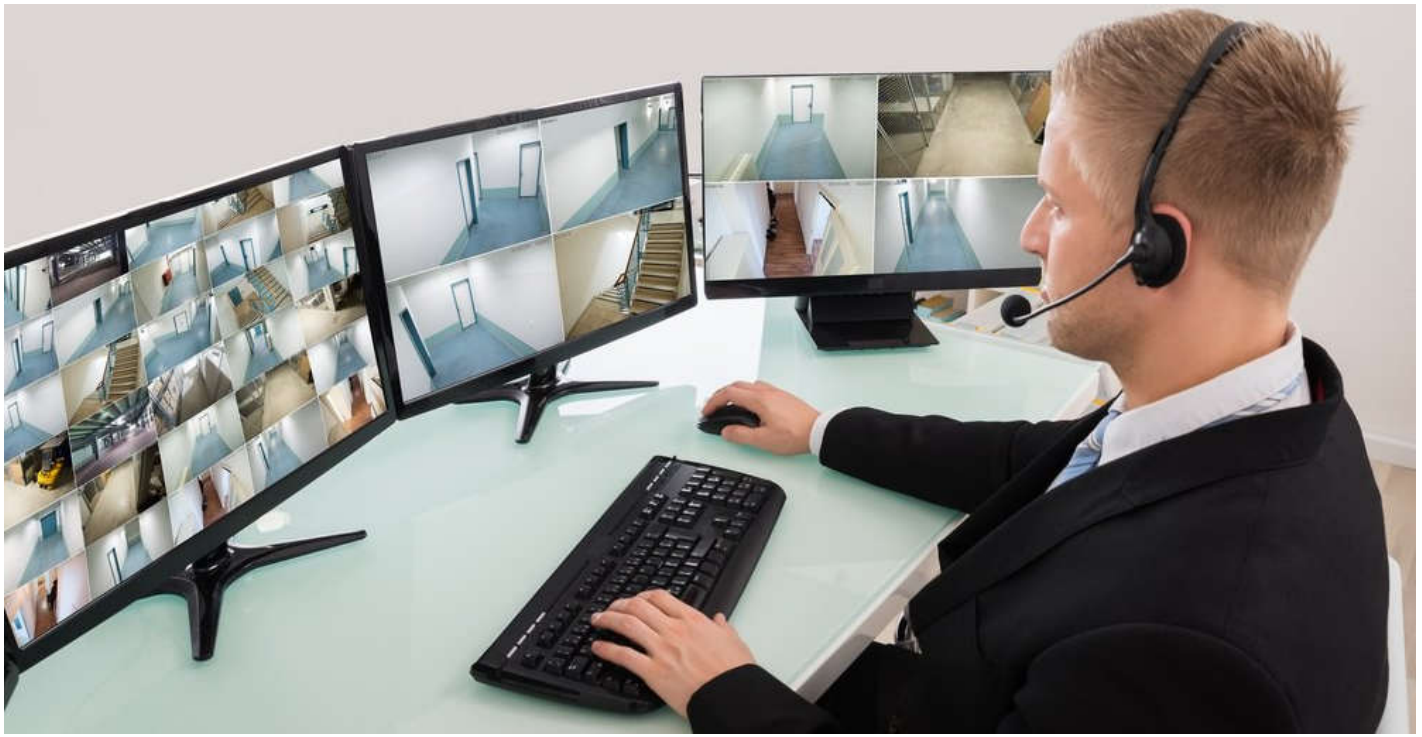
- Internet protocol (IP) cameras
  - Connect to the network rather than to a digital video recorder (DVR) using a coax cable
  - The IP camera system includes not only the cameras but also the video recording system
  - Network infrastructure
  - Power over Ethernet (PoE): enough power to support IP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

IP camera system diagram



(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)



(Source: https://mammothsecurity.com/talking-cctv/)

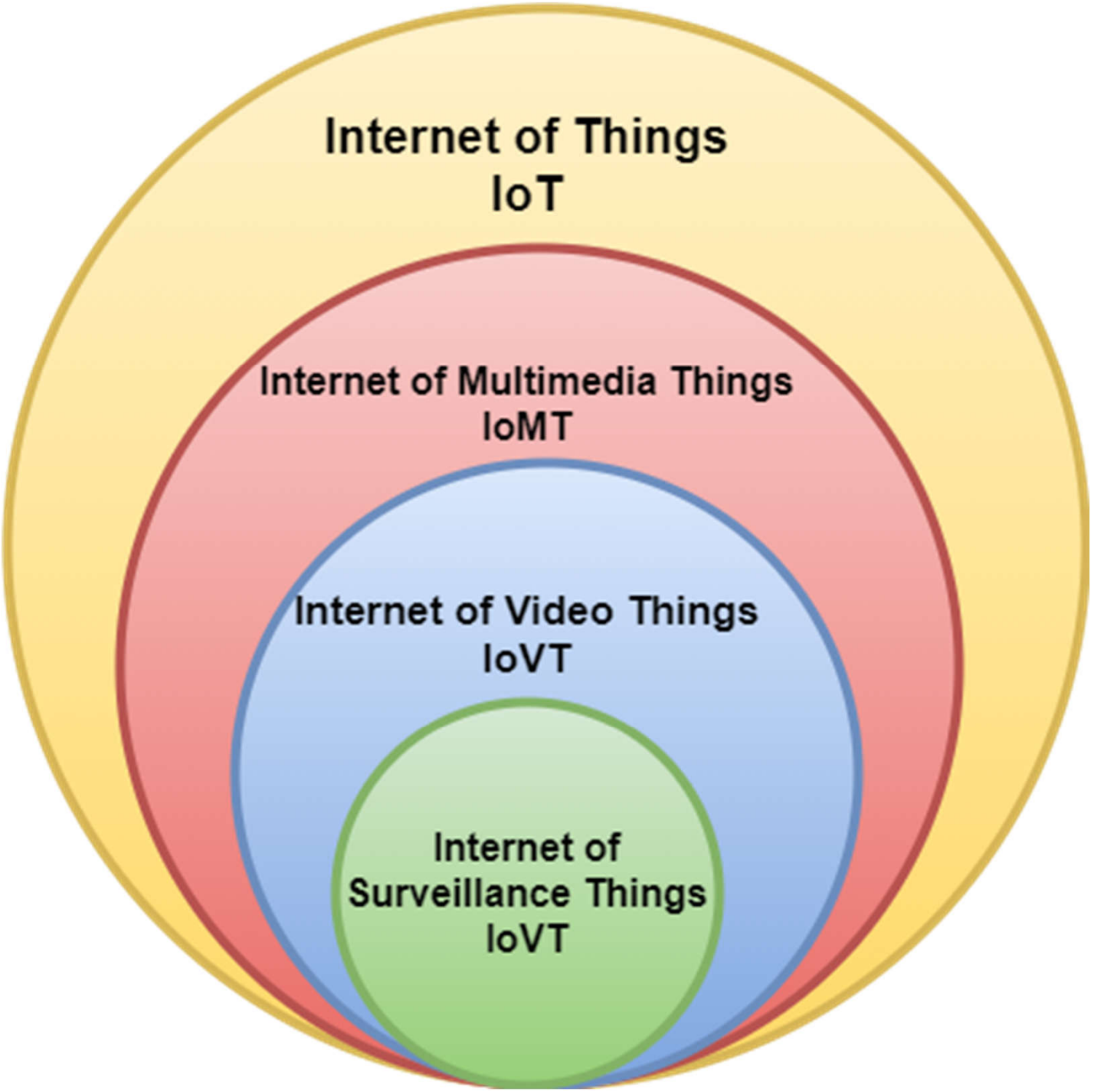
Video surveillance

- 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)

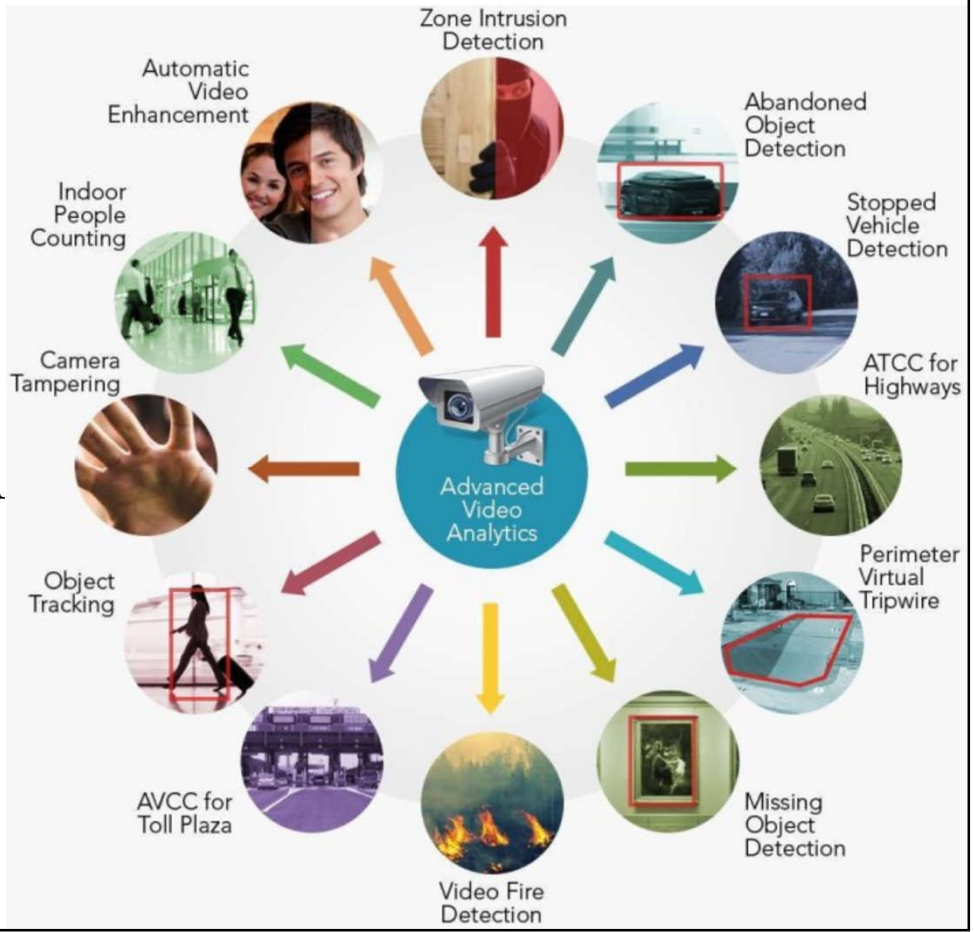
Internet of Video Things (IoVT): Future of video surveillance systems



(Source: https://benrazekalaeddine.medium.com/itecturewhat-is-internet-of-video-things-iovt-1f2323e02a0b)

Video surveillance

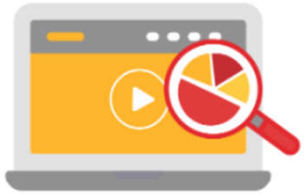
- Video surveillance & analytics (VSA)
- Key features:
  - People counting
  - Dwell time & loitering
  - Facial recognition
  - Demographics & emotion
  - Forensic search
  - Dynamic masking
  - Heat map analysis



Key features of video surveillance & analytics (VSA)

Dwell time and loitering

Facial recognition



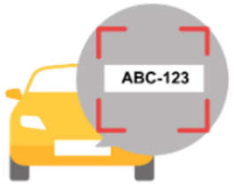
Forensic search

Demographics and emotion analysis

Dynamic masking

Heat map analysis

Motion detection



License plate recognition

Object tracking

Crowd analysis

Queue management

Suspect tracking

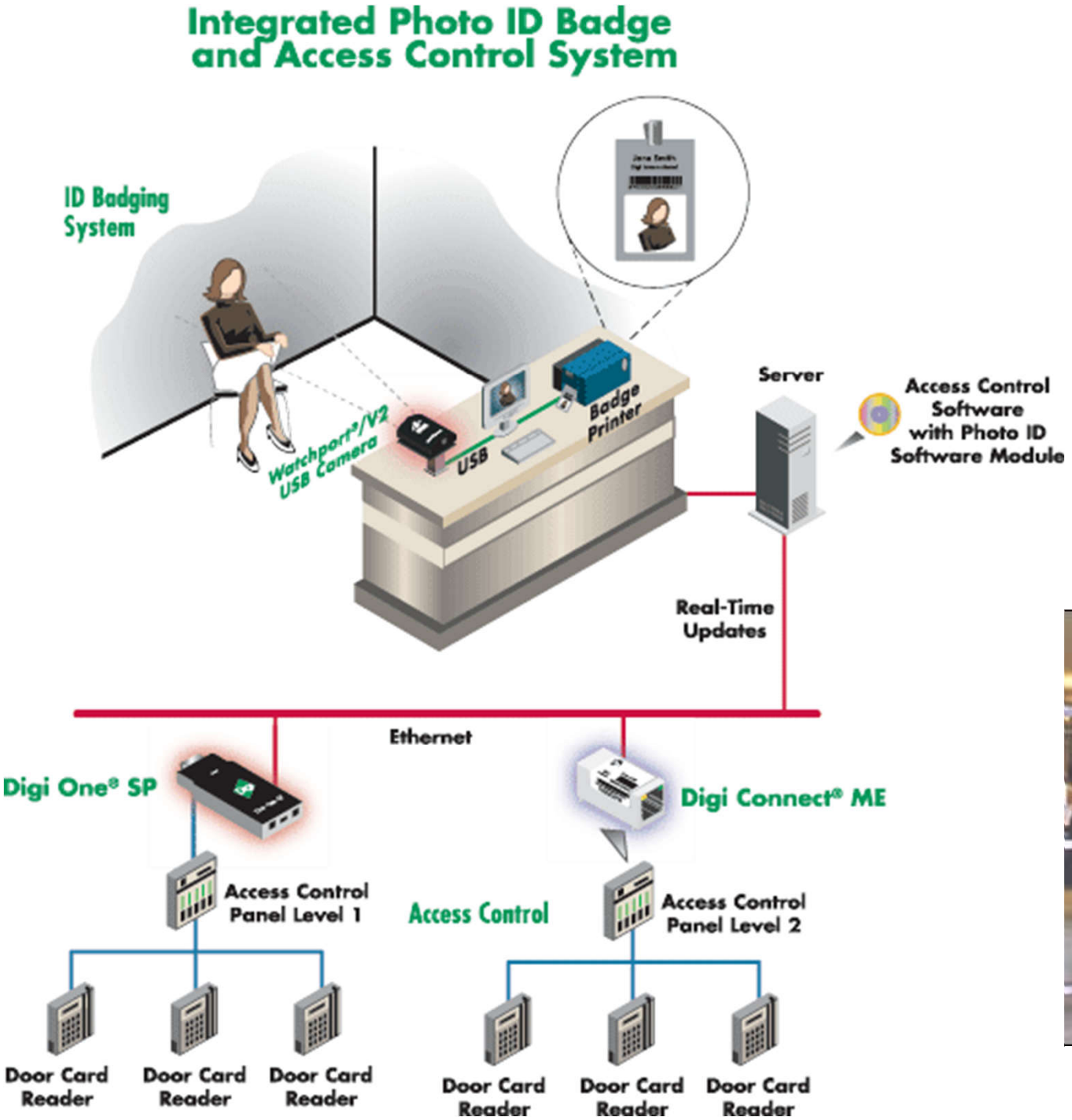
(Source: https://www.ricoh.com.hk/en/hybrid-workplace/video-surveillance-and-analytics)

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)

(* See also: Introduction to Access Control Systems https://www.silvaconsultants.com/intro-to-access-control-systems)

Access control system

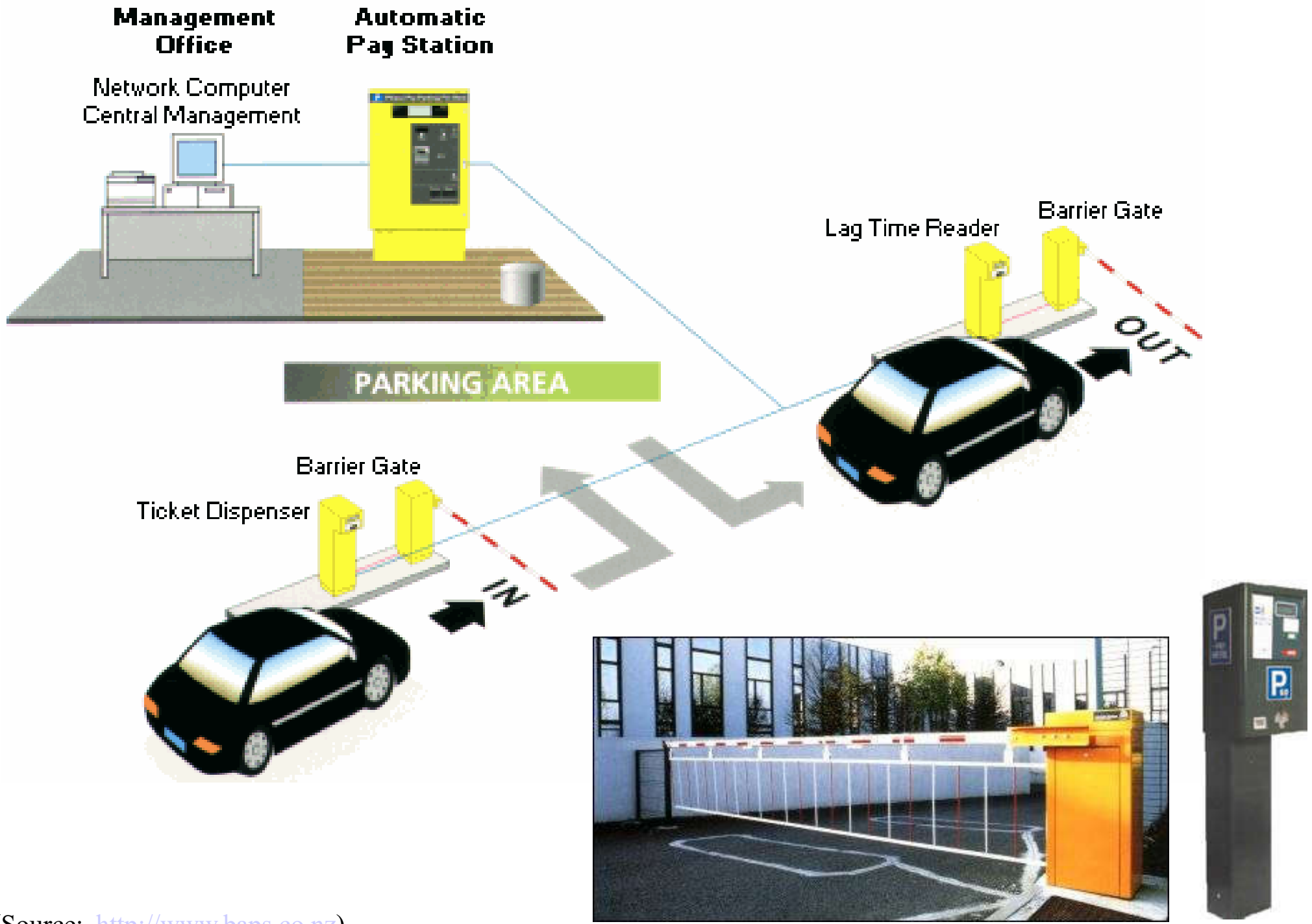


(Source: www.digi.com)

Pedestrian turnstiles

(Source: http://www.baps.co.nz)

Car park control system

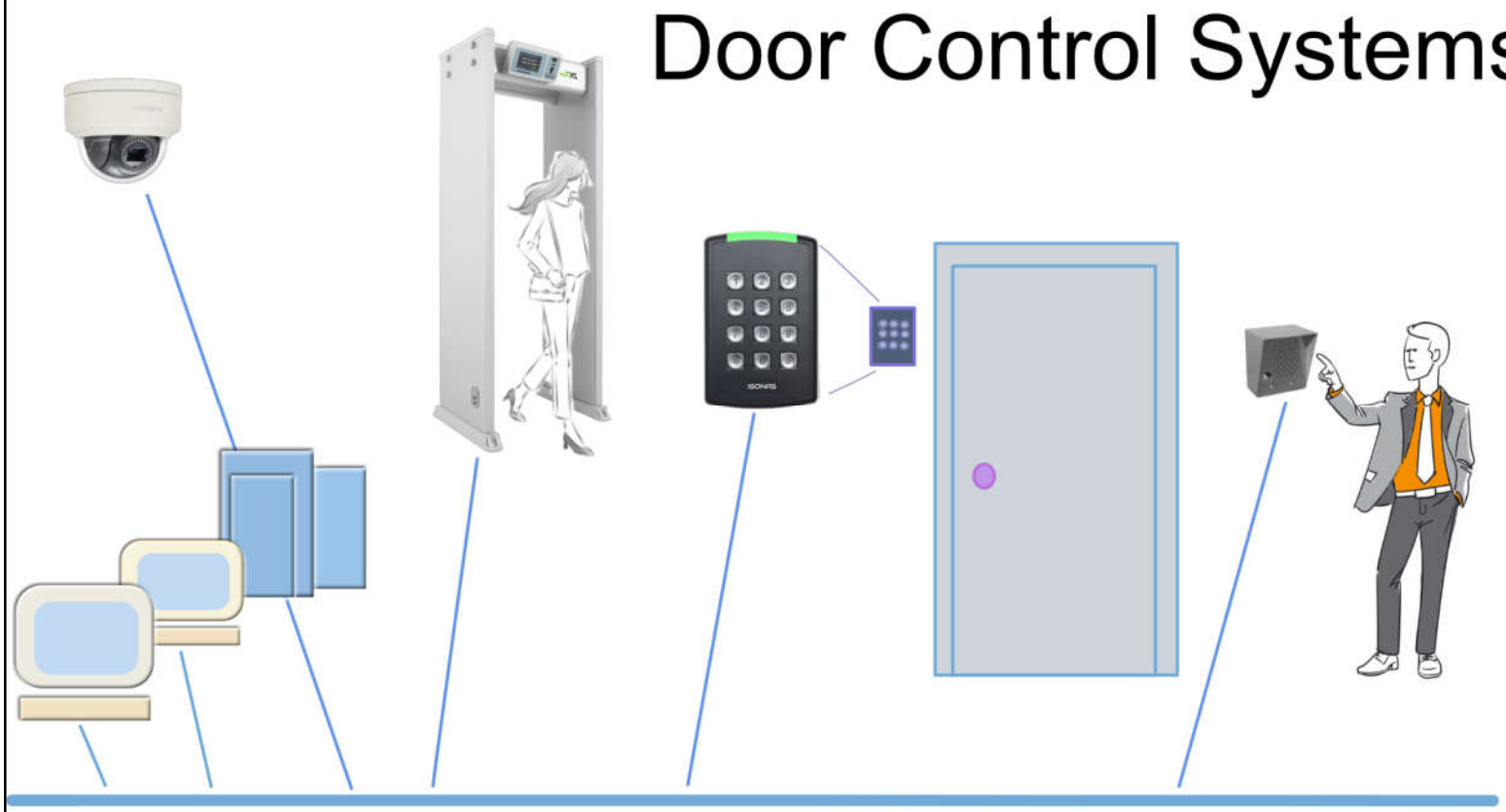


(Source: http://www.baps.co.nz)

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)



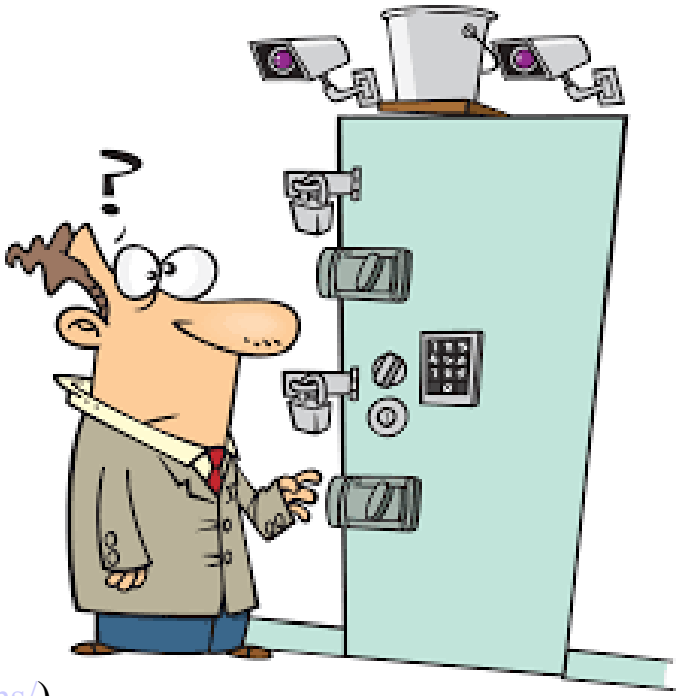
What are the key factors for door access control?

(Source: https://kintronics.com/security-provided-access-control-systems/)

Various levels of security for door access control systems

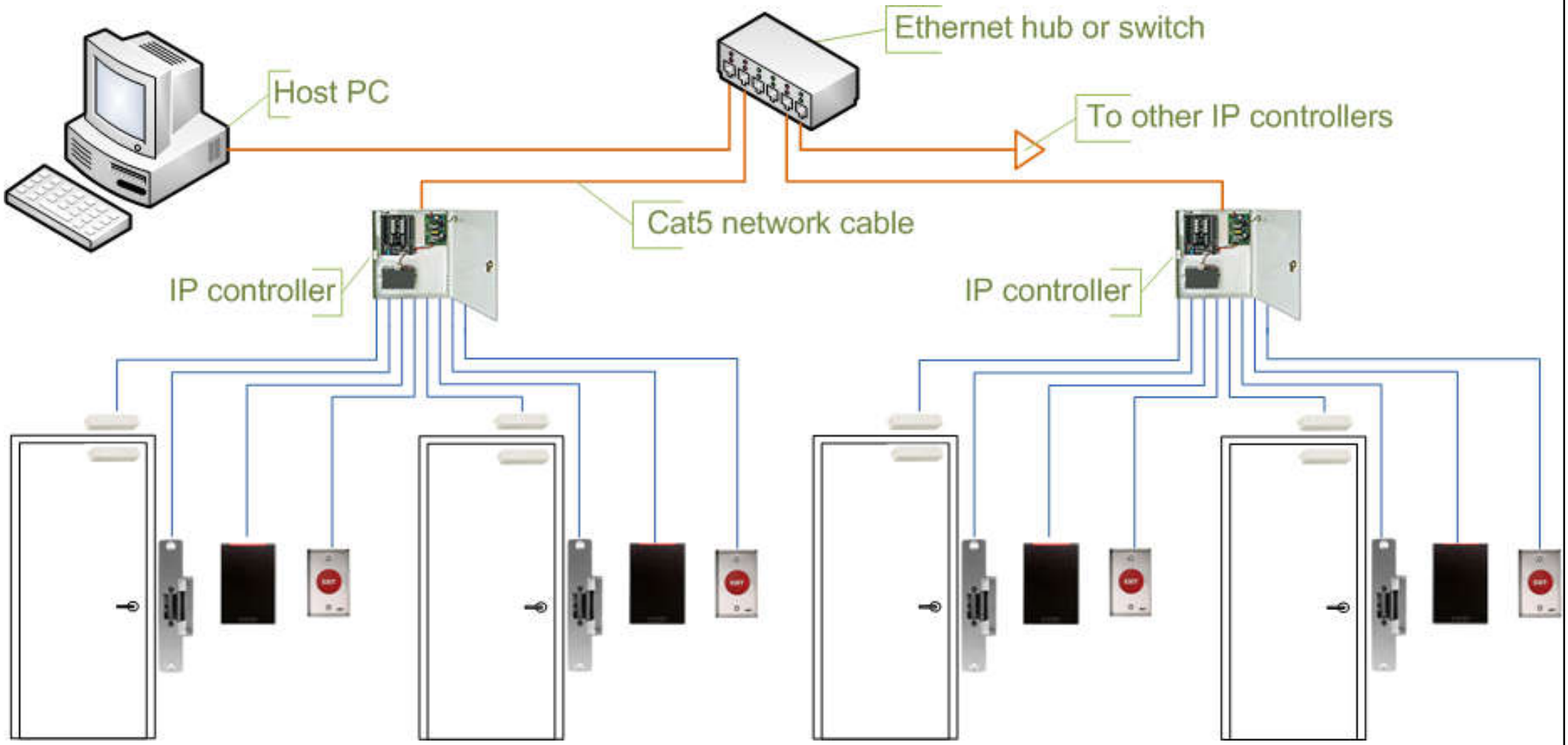
Level 1 Security – PIN Numbers	Lock with keypad Door Reader with keypad
Level 2 Security – Credentials	RFID IP Reader Intelligent IP Reader
Level 2.5 Credentials With Video	
Level 3 Security – Dual Authentication Systems	RFID IP Reader Intelligent IP Reader with Keypad
Level 3.5 Dual Authentication Plus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

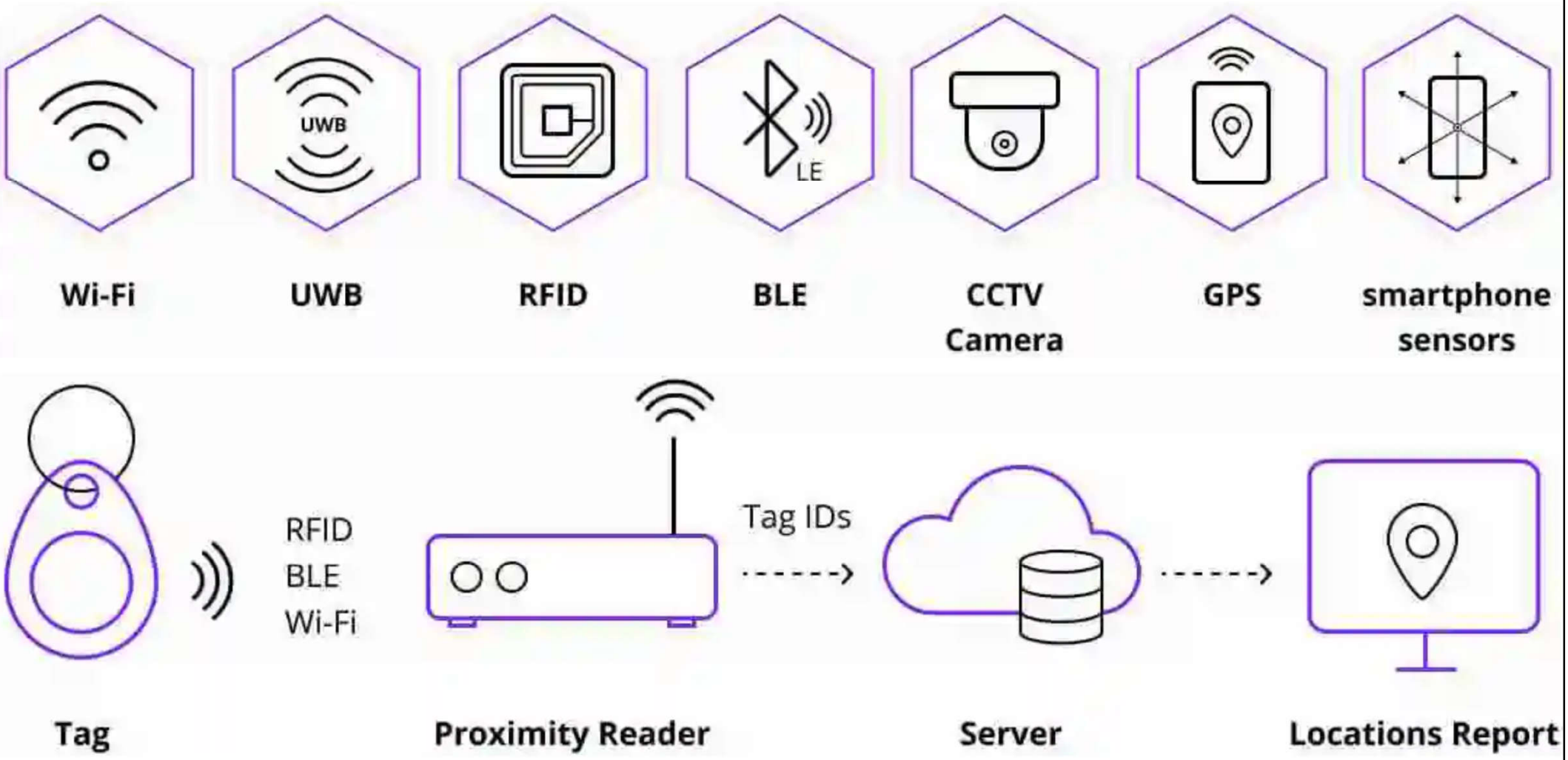


(Source: Access control - Wikipedia http://en.wikipedia.org/wiki/Access_control_system)

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



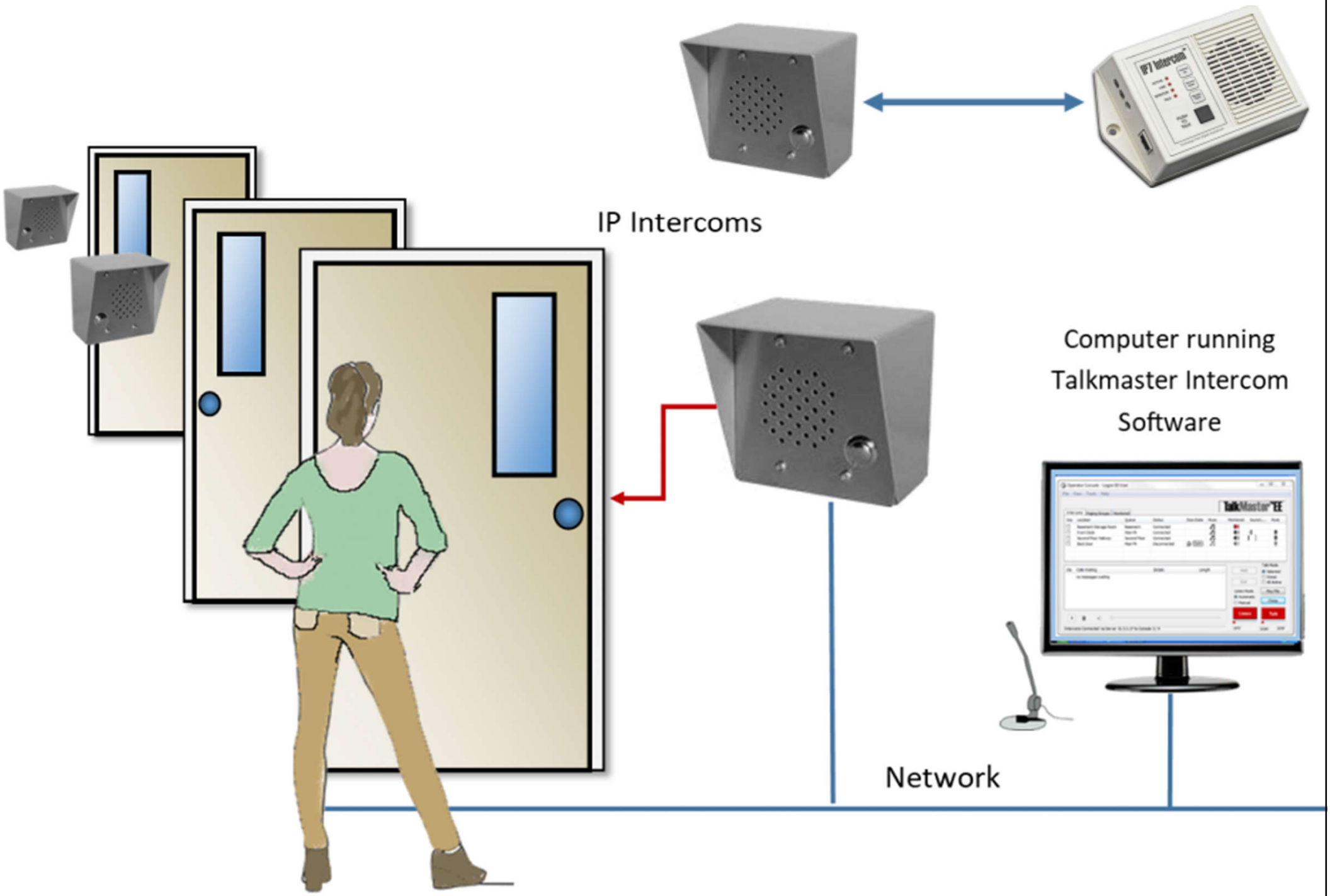
BLE = Bluetooth low-energy beacons
CCTV = Close-circuit television
GPS = Global positioning system
RFID = Radio frequency identification
UWB = Ultra-wideband

(Source: https://euristiq.com/indoor-positioning-system-the-profit-boosting-technology/)

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

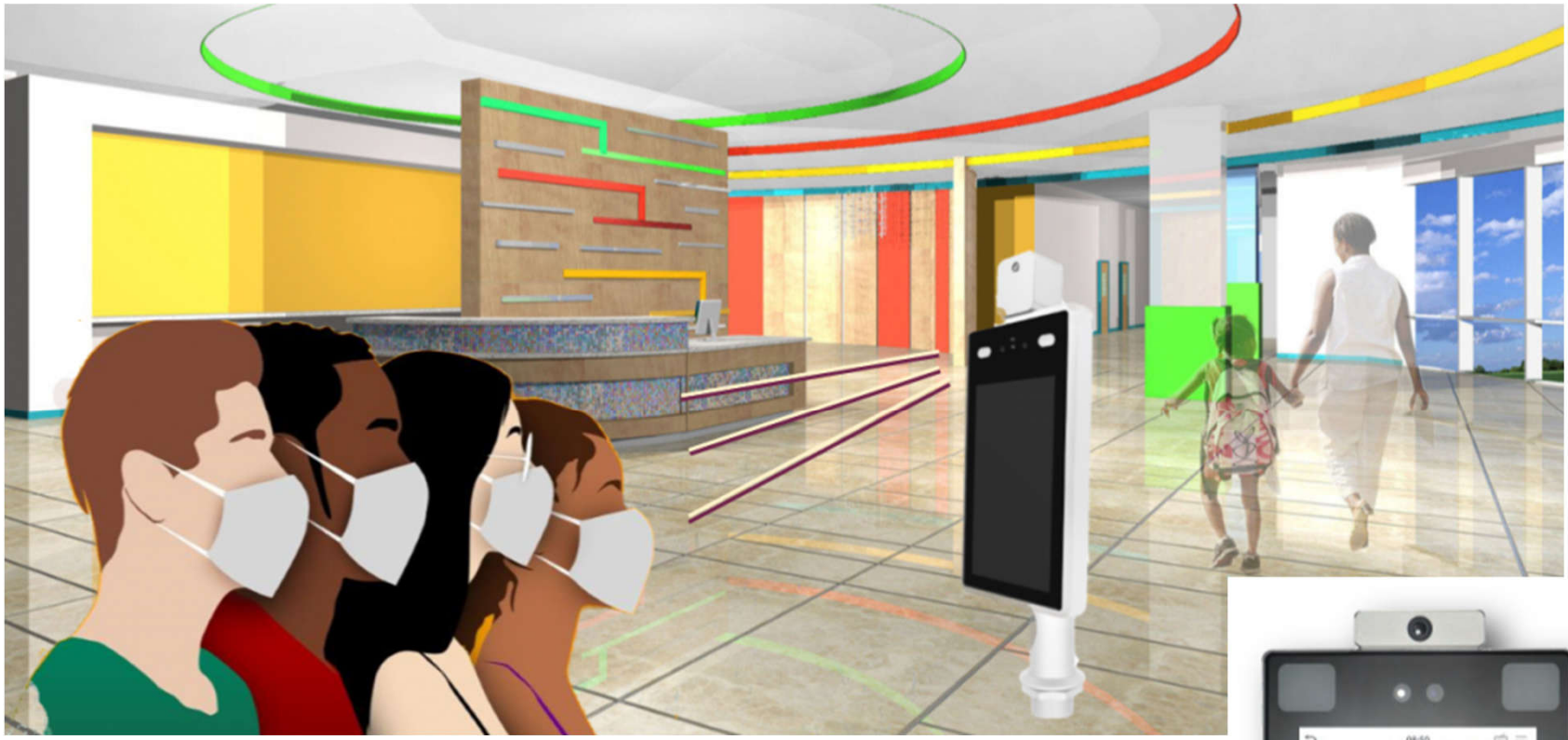


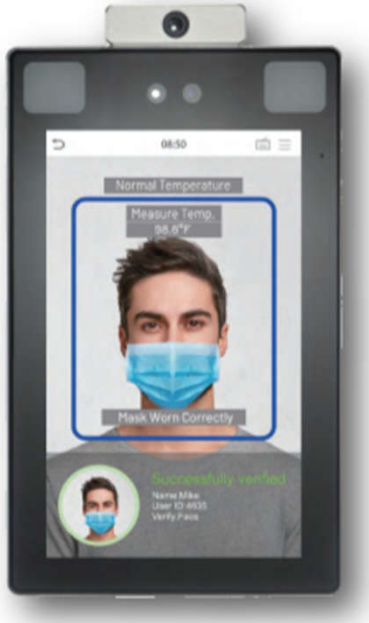
(Source: https://kintronics.com/ip-intercom-selection-and-comparison/)

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

(Source: https://kintronics.com/solutions/ip-door-access-control/comparison-of-face-recognition-and-temperature-access-control-panels/)

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**

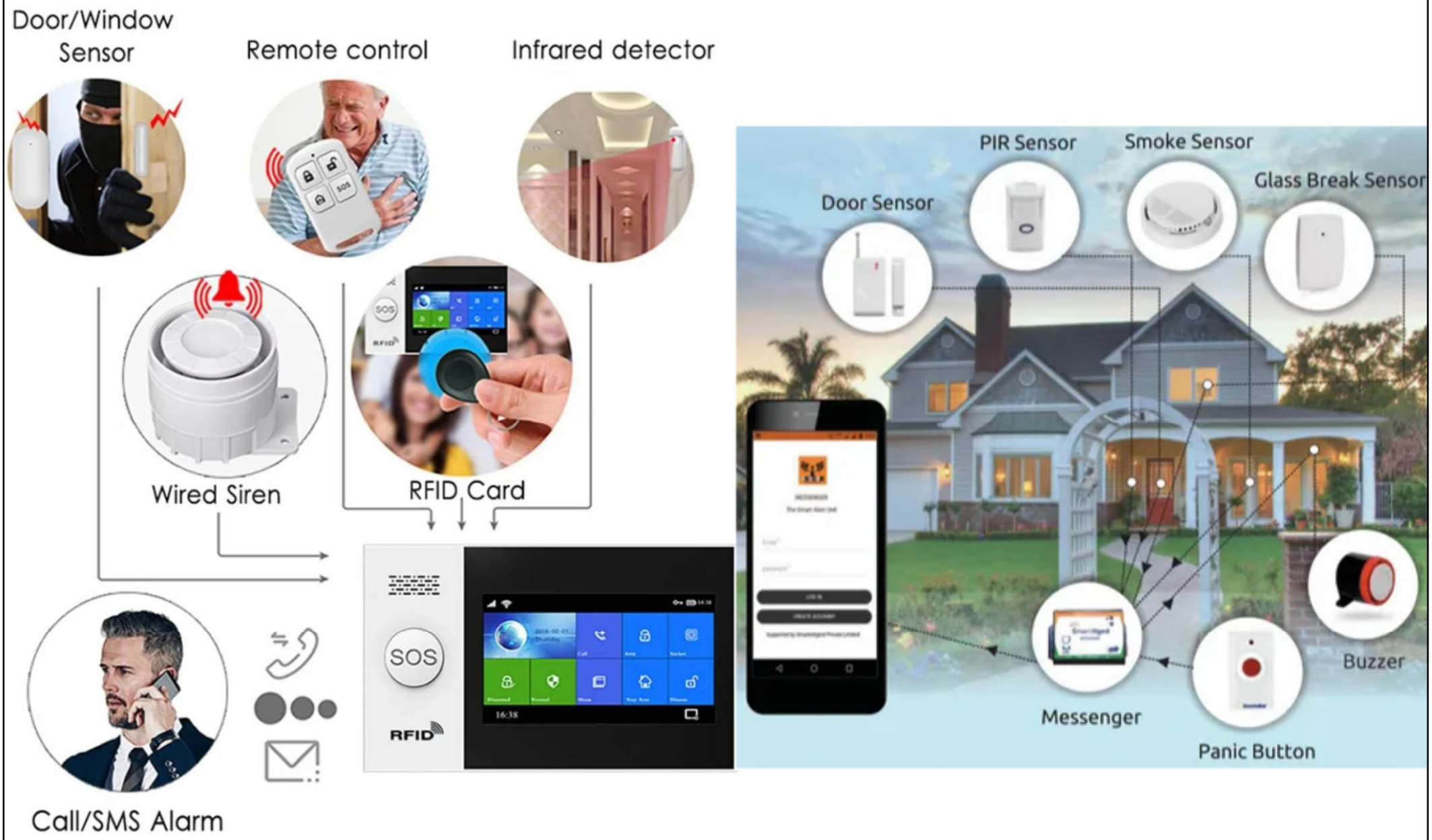
Input	Control	Output
Sensors	Panel	- Bell, siren, light - Dialer, email - Police-connect

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

Annunciation/
alarm signaling

(* See also: Alarm Systems – An Overview http://www.shieldjournal.com/alarm-systems-an-overview/)

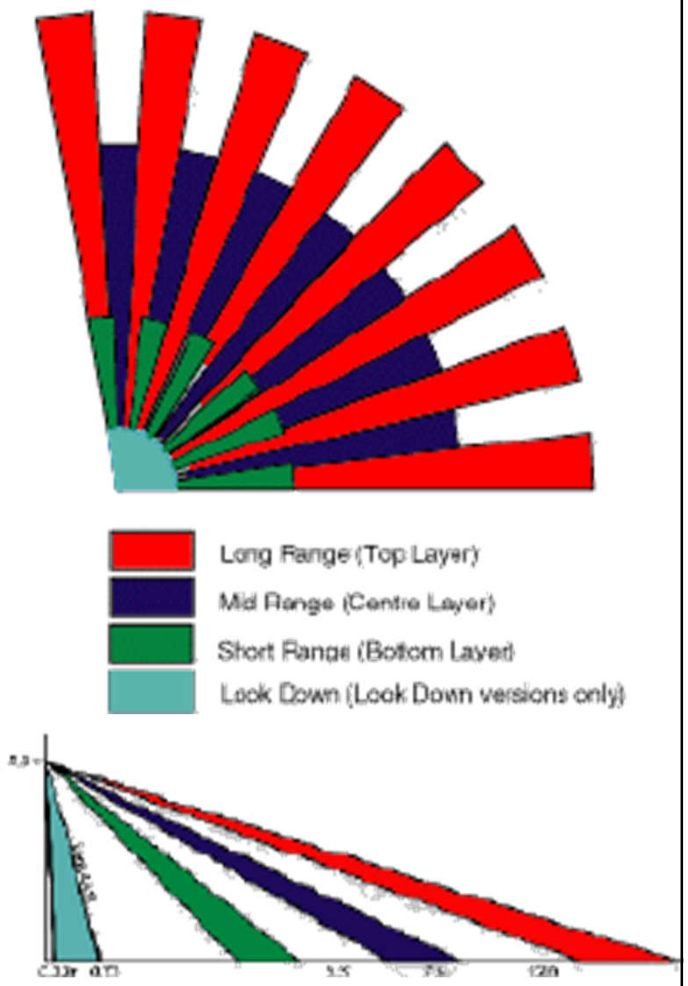
Typical components of a burglar alarm system



(Source: https://www.indiamart.com/vishliinnovations/security-alarm-system.html)

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

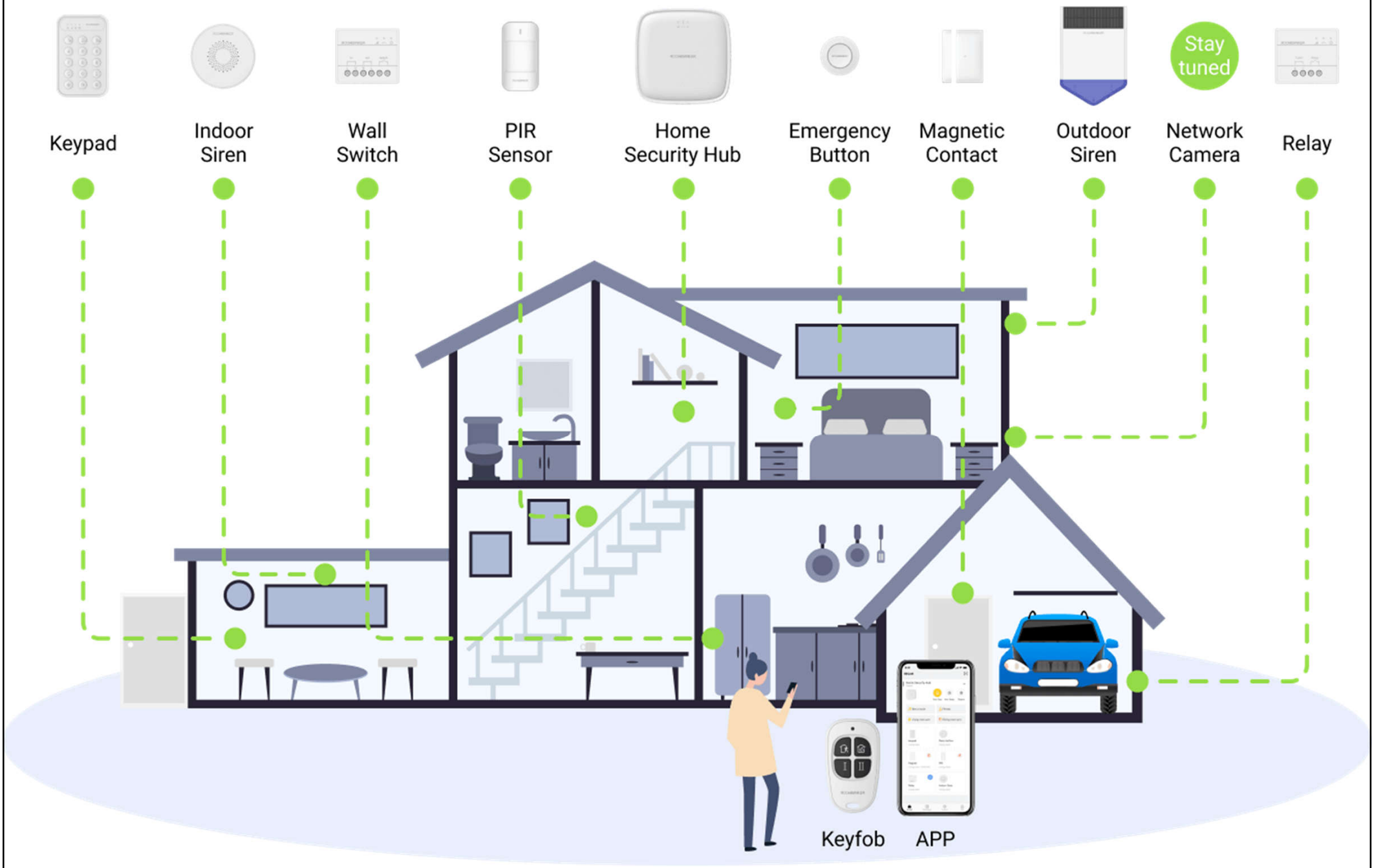


(* See also: Introduction to Intrusion Alarm Systems https://www.silvaconsultants.com/intro-to-intrusion-alarm-systems; Basic information on intruder alarm systems https://www.dipolnet.com/basic_information_on_intruder_alarm_systems_bib770.htm)

Example of an intruder detection alarm system

(Source: http://www.xpertsecurity.com)

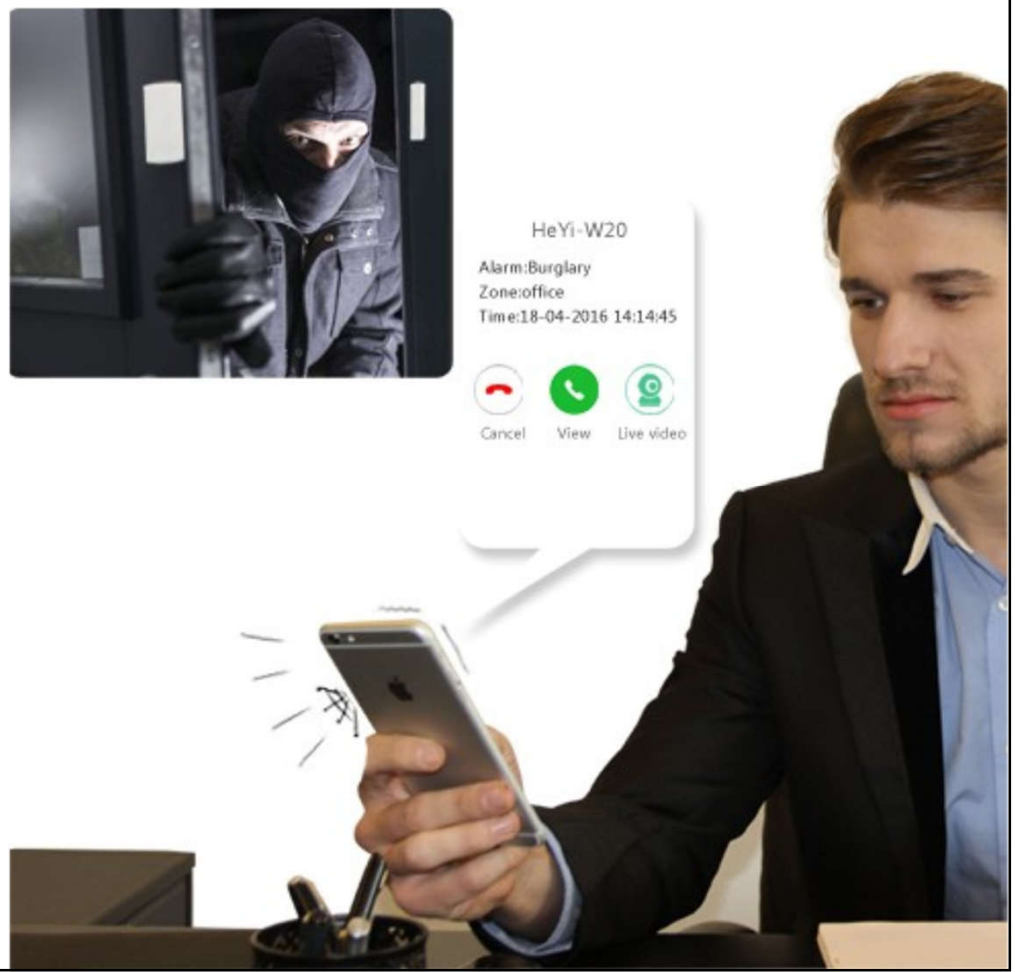
Components of intrusion detection system



(Source: https://www.roombanker.com/solution/intrusion-detection/)

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 !! →



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