

# IDAT7219 Smart Building Technology

<http://ibse.hk/IDAT7219/>



智能大廈科技

## Facilities Management



*Ir Dr. Sam C. M. Hui*

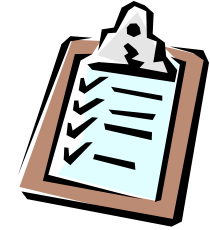
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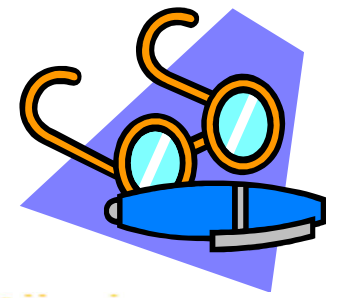
Sep 2024

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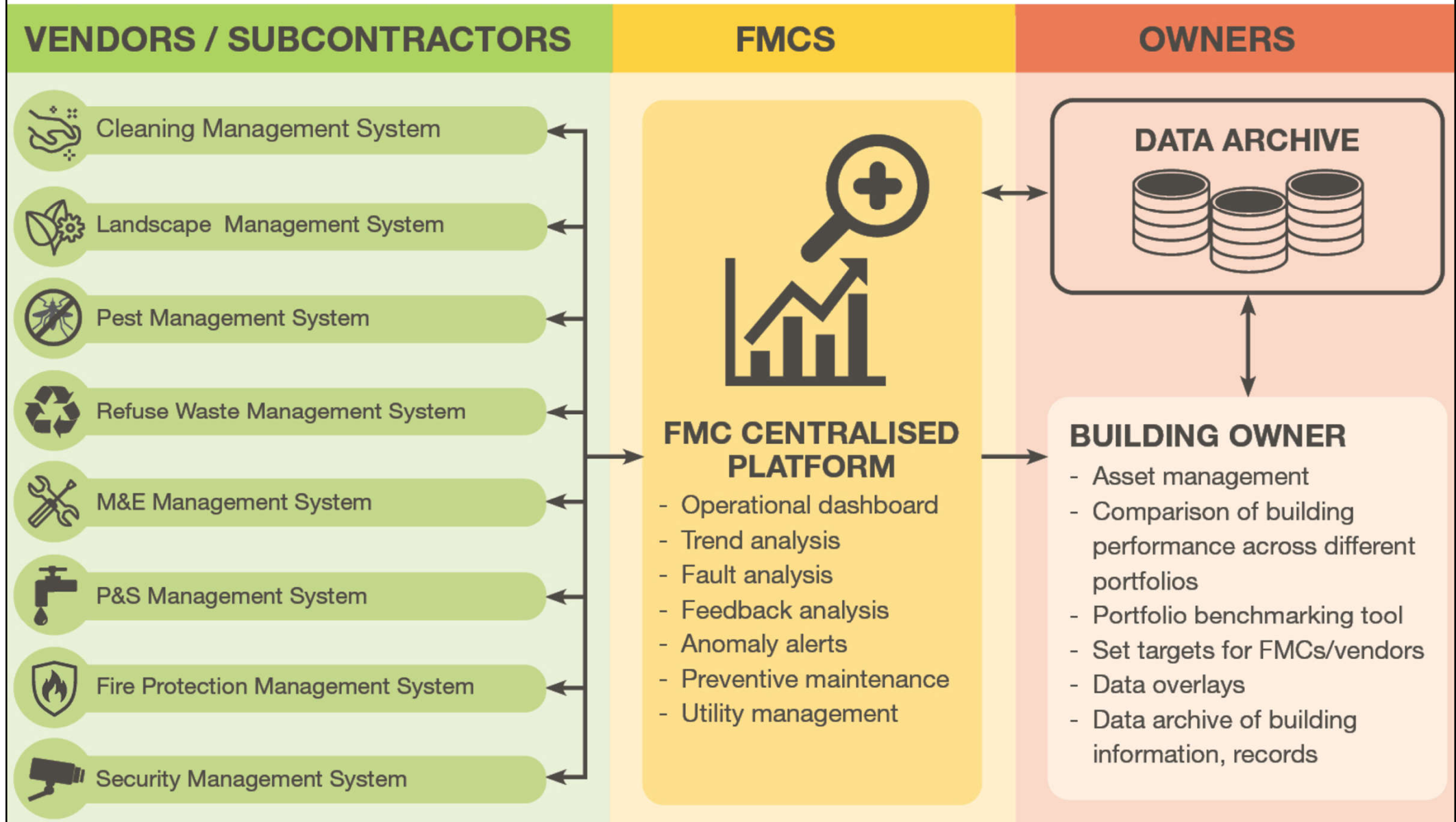
# Basic concepts



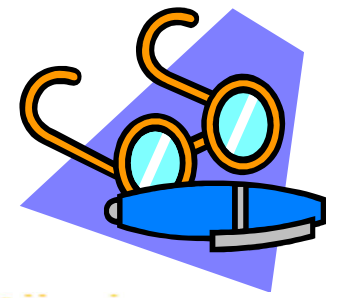
- Facilities Management (FM)

- Management of physical assets of the building
  - Commercial, retail, residential & industrial properties
  - People oriented + Process driven
- Encompass multiple disciplines to ensure functionality of the built environment by integrating people, place, process & technology
  - Manage costs & efficiencies
  - Manage spaces (e.g. for office, meeting) that can be used by individuals & groups to support a wide variety of different tasks (complete workplace management)

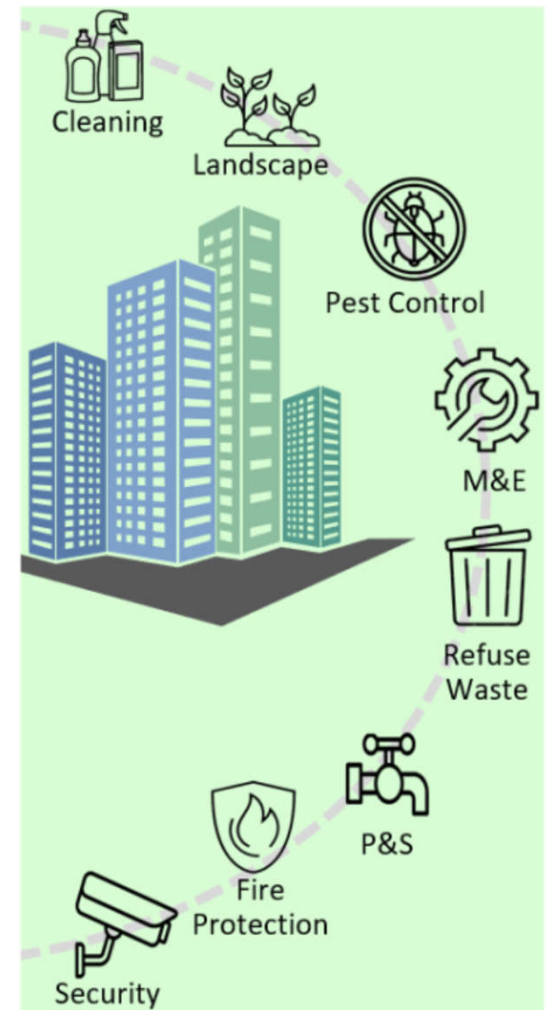
# Multiple discipline systems of facilities management & relevant stakeholders including vendors/subcontractors, facilities management companies (FMCs) & building owners



# Basic concepts



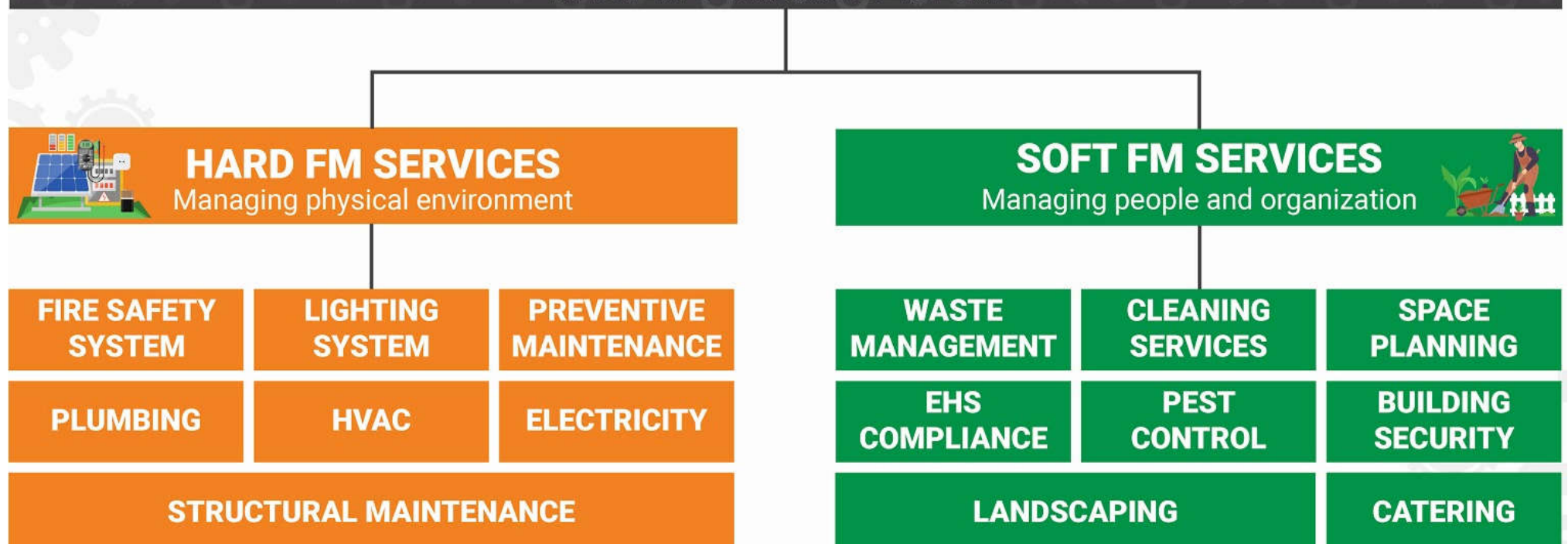
- Examples of facilities management tasks:
  - Meeting room booking
  - Visitor management
  - Cleaning service & pest control
  - Waste management
  - Security management
  - Asset maintenance & workflow
  - Vendor & subcontractor management
  - Request (helpdesk) management



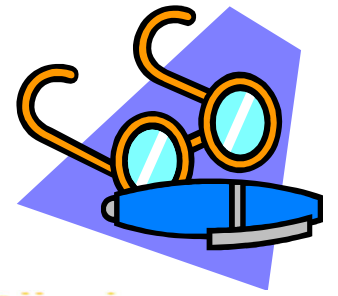
# Scope & functions of facilities management (FM)



## FACILITY MANAGEMENT

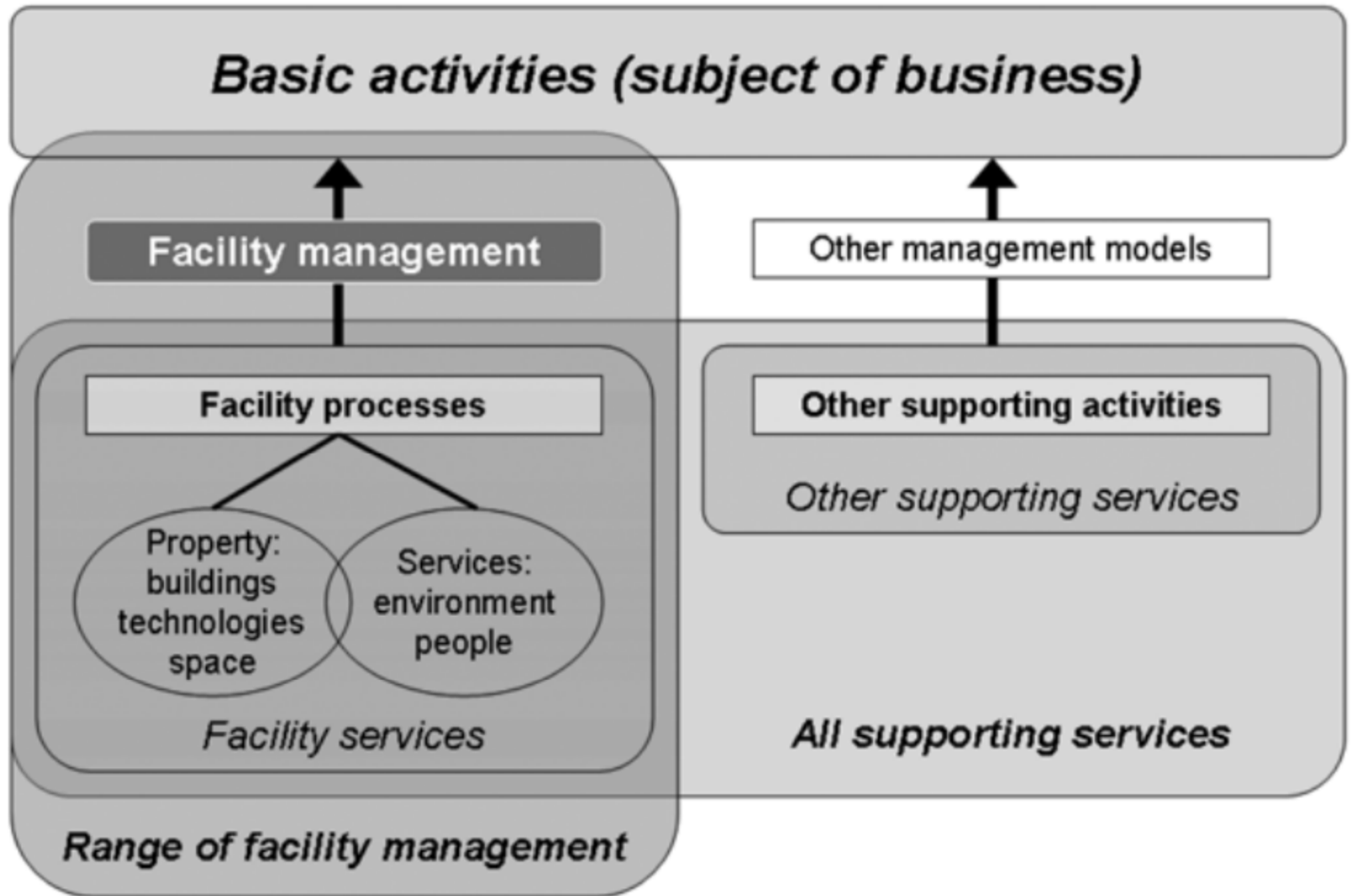


# Basic concepts



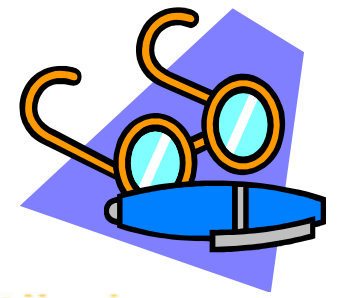
- Two areas of facilities management (FM):
  - 1) Space & Infrastructure (“hard services”)
    - Space management, space utilization, management & optimization of the workplace, technical management of buildings, energy management, waste management, indoor & outdoor cleaning
  - 2) People & Organizations (“soft services”)
    - Health, hygiene, safety & security, internal services (boarding, receptions, meeting rooms, secretarial services, etc.), ICT, internal logistics (archive services, mail service, transport services, car service, etc.)

# Structure & activities of facility management & other supporting services



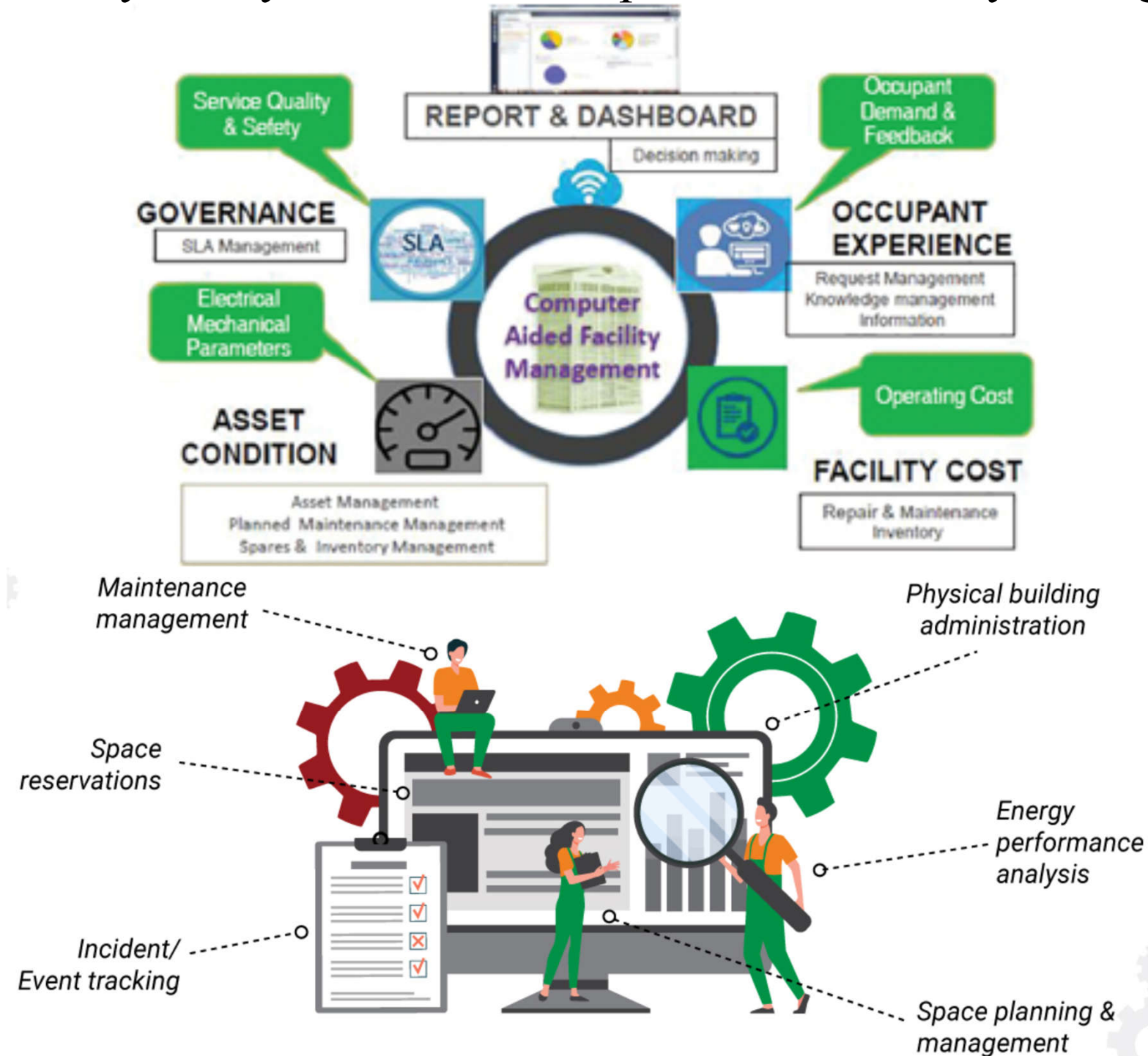


# Basic concepts

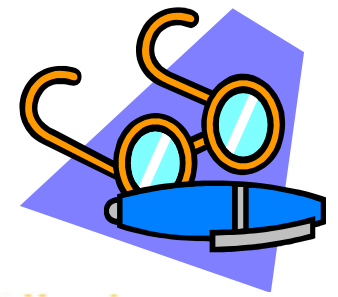


- Two software solutions/platforms for FM:
  - 1. Computer-Aided Facility Management (CAFM)
    - Space Management: track the occupancy & allocation of space
    - Move Management: plan, execute & track moves of equipment, people & furniture
    - Asset Management: track & maintain assets/equipment by scheduling usage & maintenance activities
    - Maintenance Management: manage & schedule maintenance activities, track the progress of work & generate reports

# Functionality & key features of computer-aided facility management



# Basic concepts



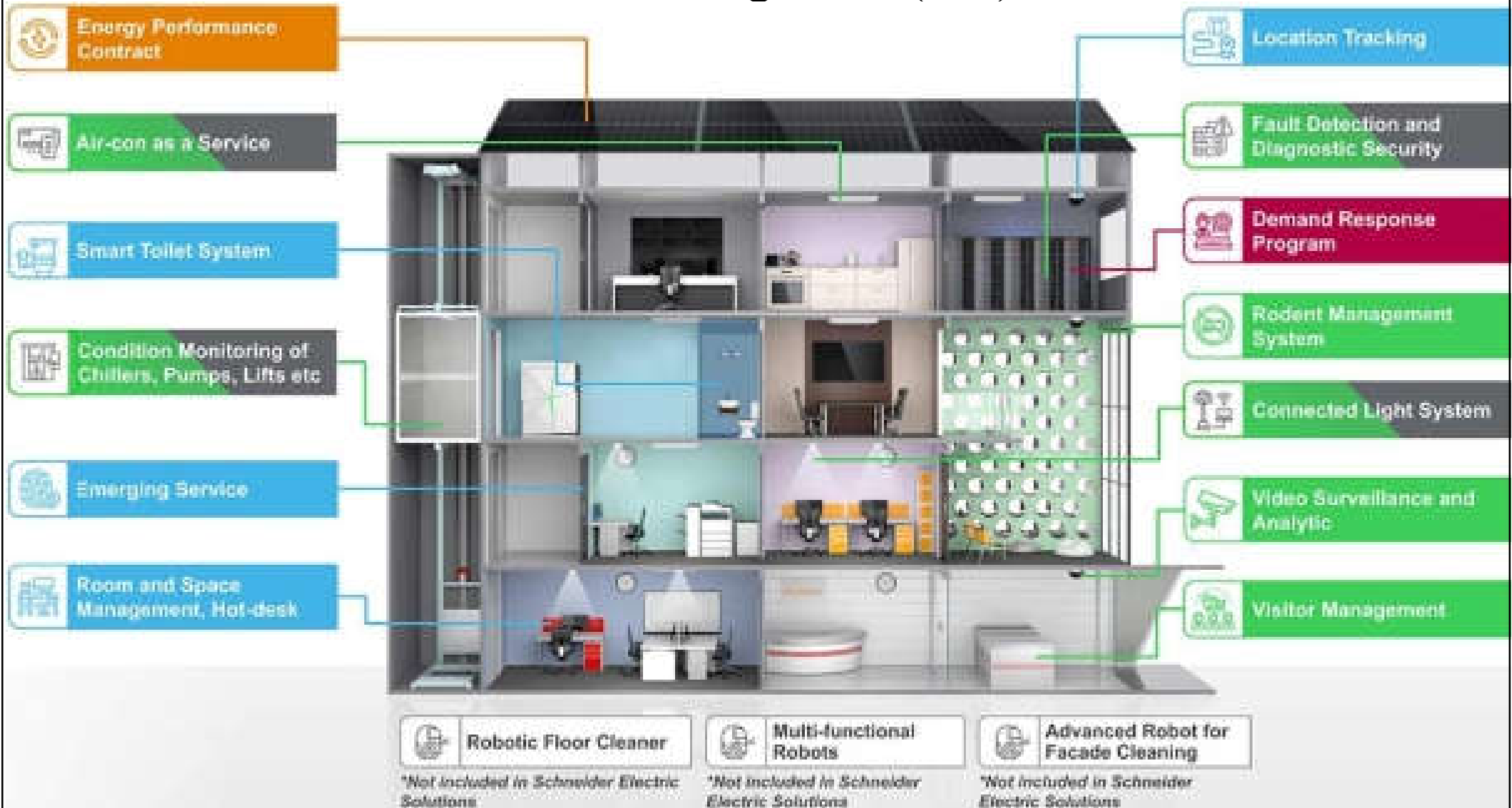
- Two software solutions/platforms for FM:
  - 2. Computerized Maintenance Management System (CMMS)
    - Work Order Management: create, schedule & track work orders related to maintenance activities.
    - Asset Management: track & maintain assets, schedule maintenance activities & track their usage
    - Inventory Management: manage spare parts & inventory related to maintenance activities
    - Reporting: generate reports related to maintenance activities, inventory & assets

# An example of facilities management (FM) software interface



(Source: <https://www.velistech.com/blog-article/difference-between-cafm-and-cmms-a-quick-guide>)

# Smart facilities management (FM) services



People counting/  
occupancy



Door sensing



Water leakage



Temperature  
control



Air quality  
monitoring

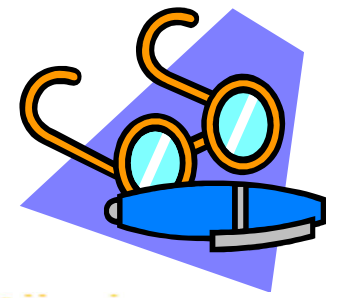


Smart parking



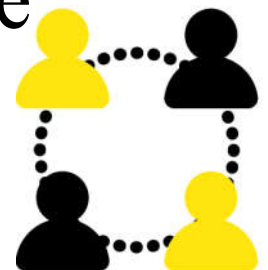
Smart restroom

# Smart FM

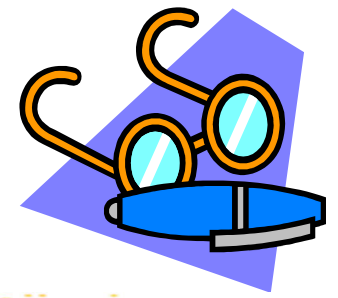


- Smart Facilities Management (FM) refers to the integration of systems, processes, technologies & personnel to enhance the management of a building's facilities
  - Coordination of space, infrastructure, people, & organization based on smart sensing, computational intelligence & networks
  - Enhance connection & collaboration to manage day-to-day work & increase productivity

智能物業管理



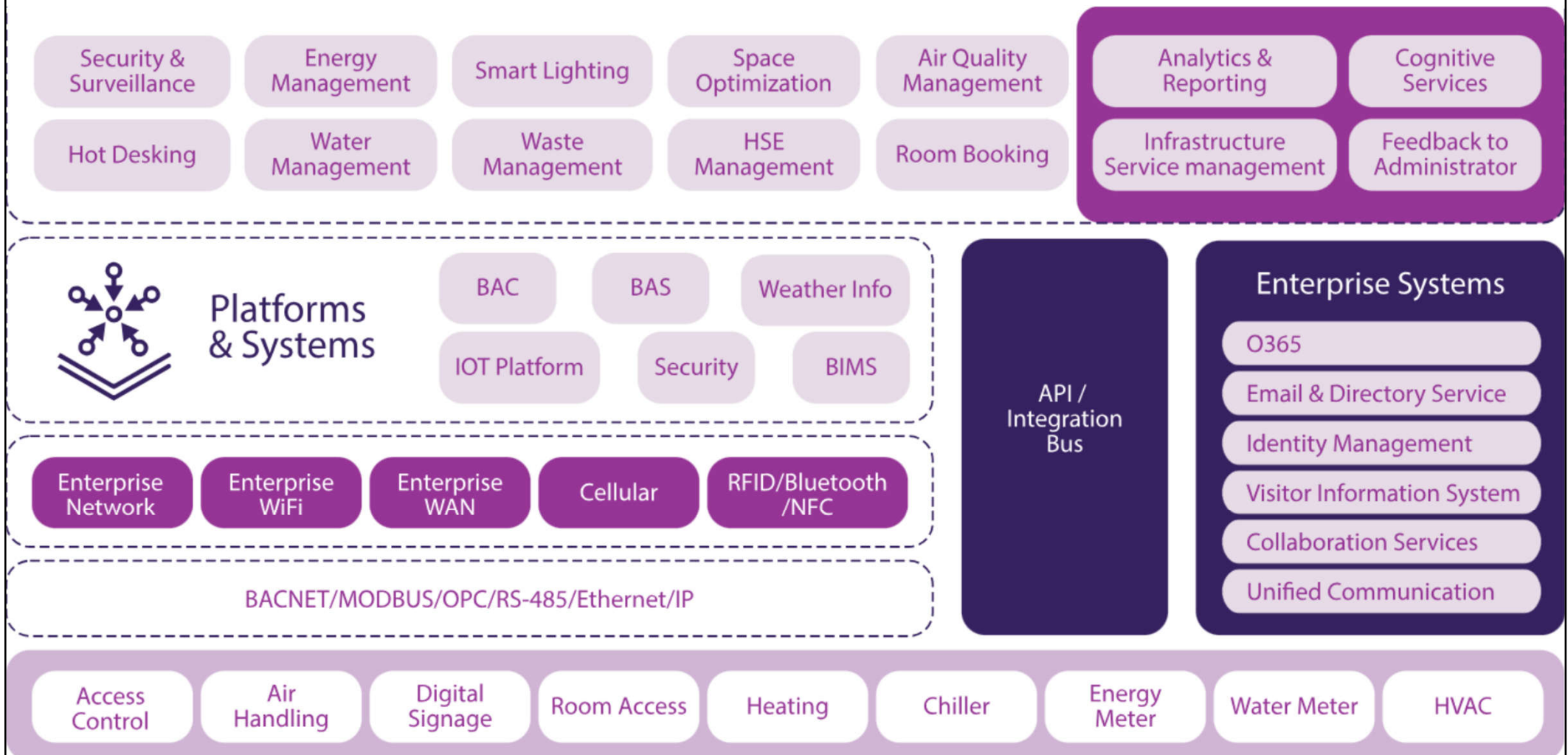
# Smart FM



- Smart facilities management functions:
  - 1. Smart energy management
  - 2. Smart maintenance management
  - 3. Smart indoor occupant comfort management
  - 4. Smart space management
  - 5. Smart traffic management
  - 6. Smart security management
  - 7. Smart document code & transaction management

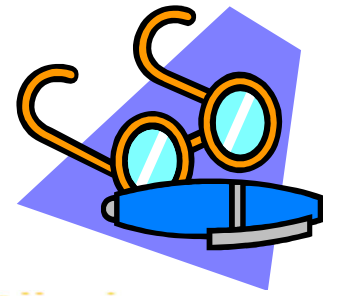


# Major areas & functions of smart facilities management (SFM)





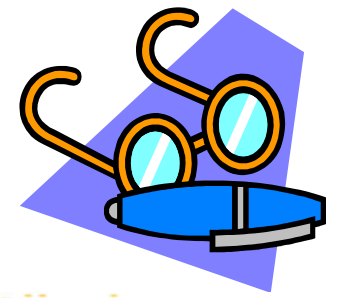
# Smart FM



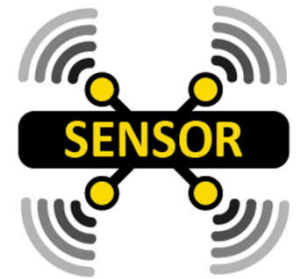
- With Smart FM, people can:
  - Access all facility status & data from a single dashboard/panel
  - Get notifications from sensors on building management tasks, e.g. when bathrooms need cleaning, or lights bulbs need changing
  - Achieve greater transparency on energy costs & savings breakdown
  - Perform preventive maintenance instead of reactive maintenance
  - Gather data & analytics to drive informed decisions



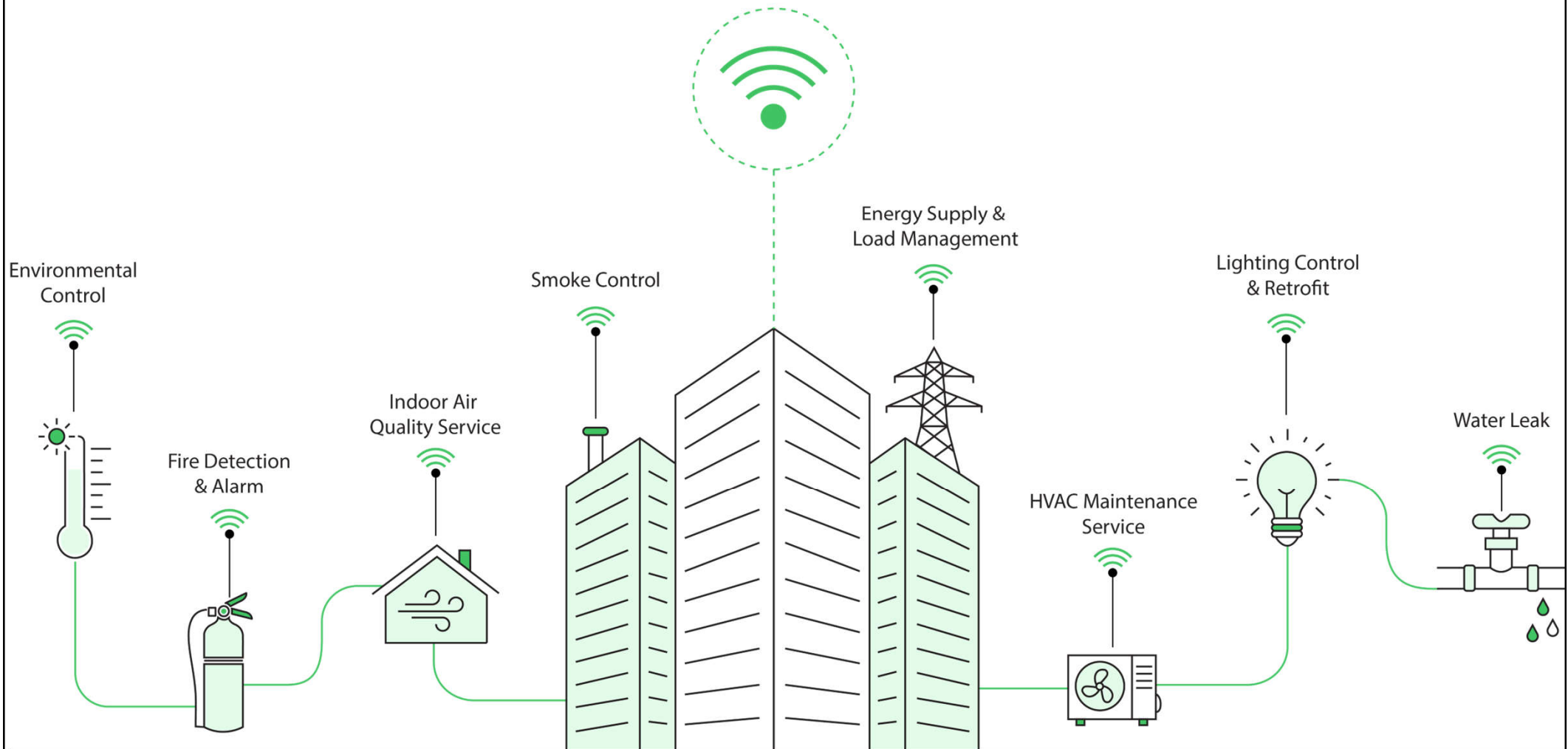
# Smart FM



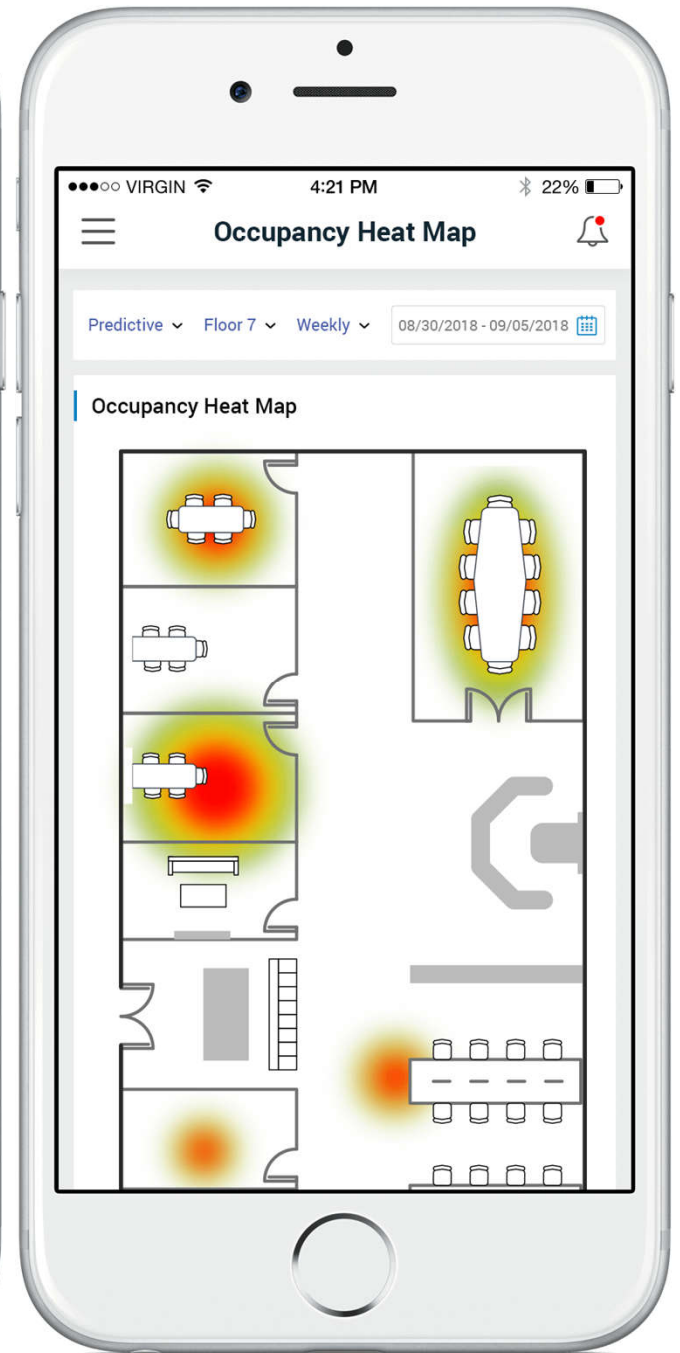
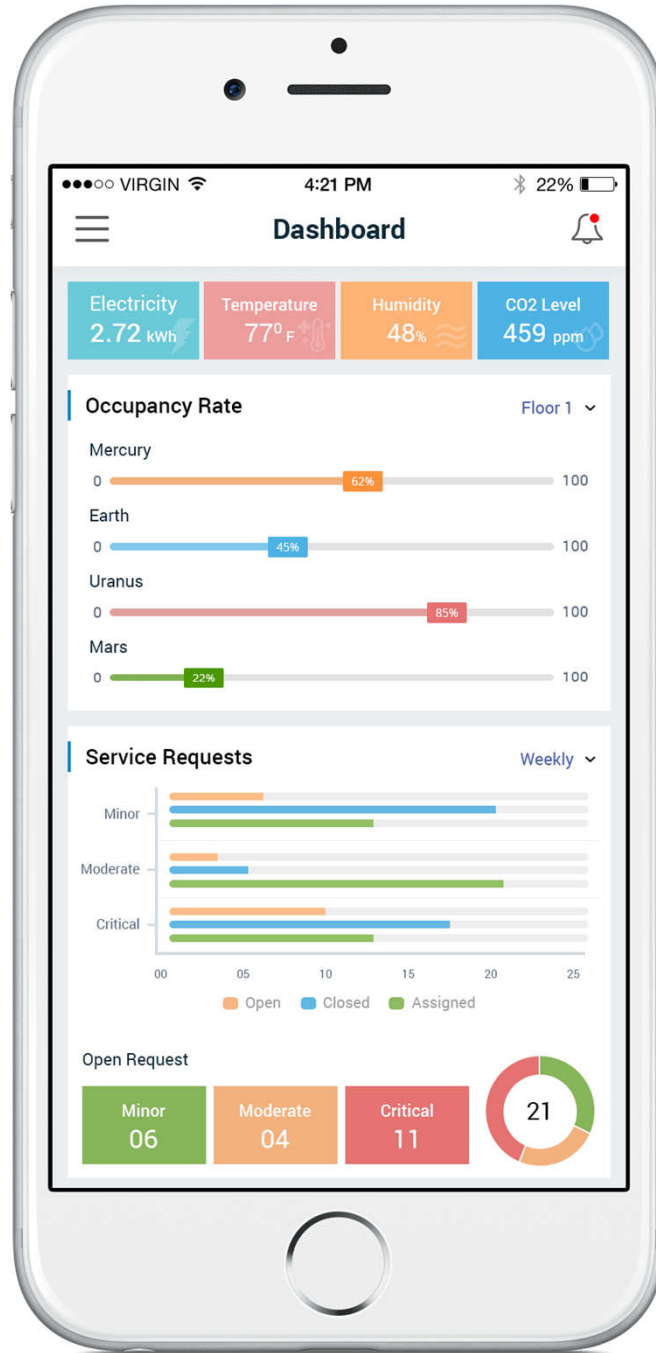
- Features of smart facilities management:
  - Interoperable control systems
  - IoT sensory devices (e.g. leakage detection)
  - Automated building systems diagnostics
  - Self-commissioning of building systems (sensors & control systems)
  - Effective management of device connectivity & network infrastructure
  - Optimum working & business environment



# Features of smart facility monitoring solution

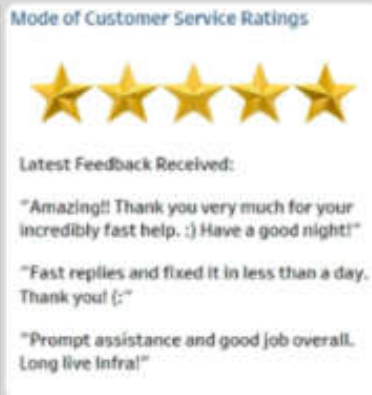
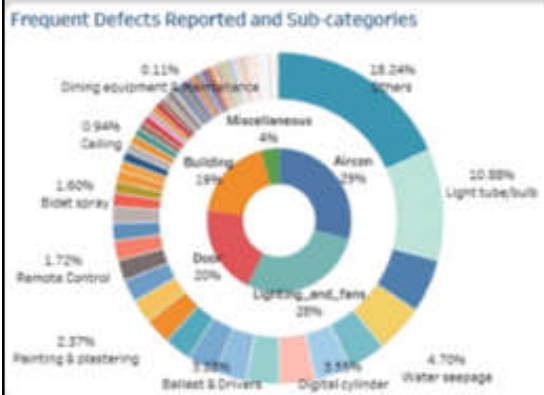


# Example of smart facility monitoring solution on mobile phone



# Smart facilities management dashboard

## Yale-NUS Aggregated Campus Health and Integrated Performance Dashboard



### Defects Reported by Infra

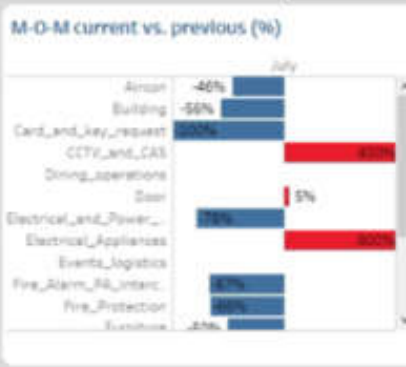
Reported By	No. of Defects	FTE Saved	No. of Defects		
			May 2022	June 2022	July 2022
Patrick Hong	702	\$790	60	112	68
Alisha Meyer	472	\$531	51	84	80
Min Sor	342	\$385	18	26	11
Jeysson Hannah	292	\$329	19	16	32
Vanitha Kapoor	263	\$296	4	2	1
Elvin Hong	263	\$296	24	9	3
Eastburn Blair	252	\$284		2	5
SK Rajah	225	\$253			
David Hartono	215	\$242	20	40	32
Desmond Tan	171	\$192	4	16	7
Ethan Wong	98	\$110	7		

### Defects Reported by Users

	Total	Resl	Comm
Jaydon Hude	29	21	8
Jacky Wu	27	17	10
Rebecca Cheong	22	20	2
Piyen Extrade	20	13	7
Nico Matthews	20	16	4
Chandrimay Ra...	19	15	4
Kalsha Chan	18	18	0
Kristie Lister	17	14	3
Alan Ng	15	14	1
Shiv Keeling	15	7	8
Klaudia Wirtza	13	12	1
Teresa Rocha	13	9	4
Gan Tat Hong	13	11	2

### Average Days to Close Defects per Category

Dining_operations	81
Building	22
Aircon	13
Others	12
Events_logistics	12
Card_and_key_request	10
Fire_Protection	9
Lift	8
Door	7
Registration_of_appl.	7
CCTV_and_CAS	6
Carpark_reservation	6



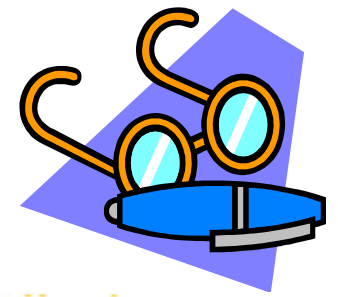
### Median Days to Close Defects

Stanley	7
Nigel Khoo	3
Daniel	2
Suresh	1
Anton	1
Siu Hui	0
Elvin	0
Rishu	0
Jackson	0
Nesly	0

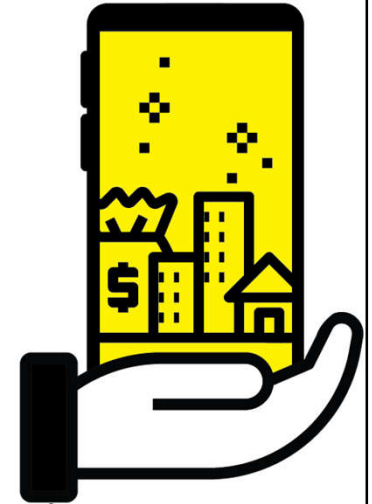


(Source: <https://www.yale-nus.edu.sg/story/yale-nus-infrastructure-office-develops-smart-facilities-management-dashboard/>)

# Smart FM

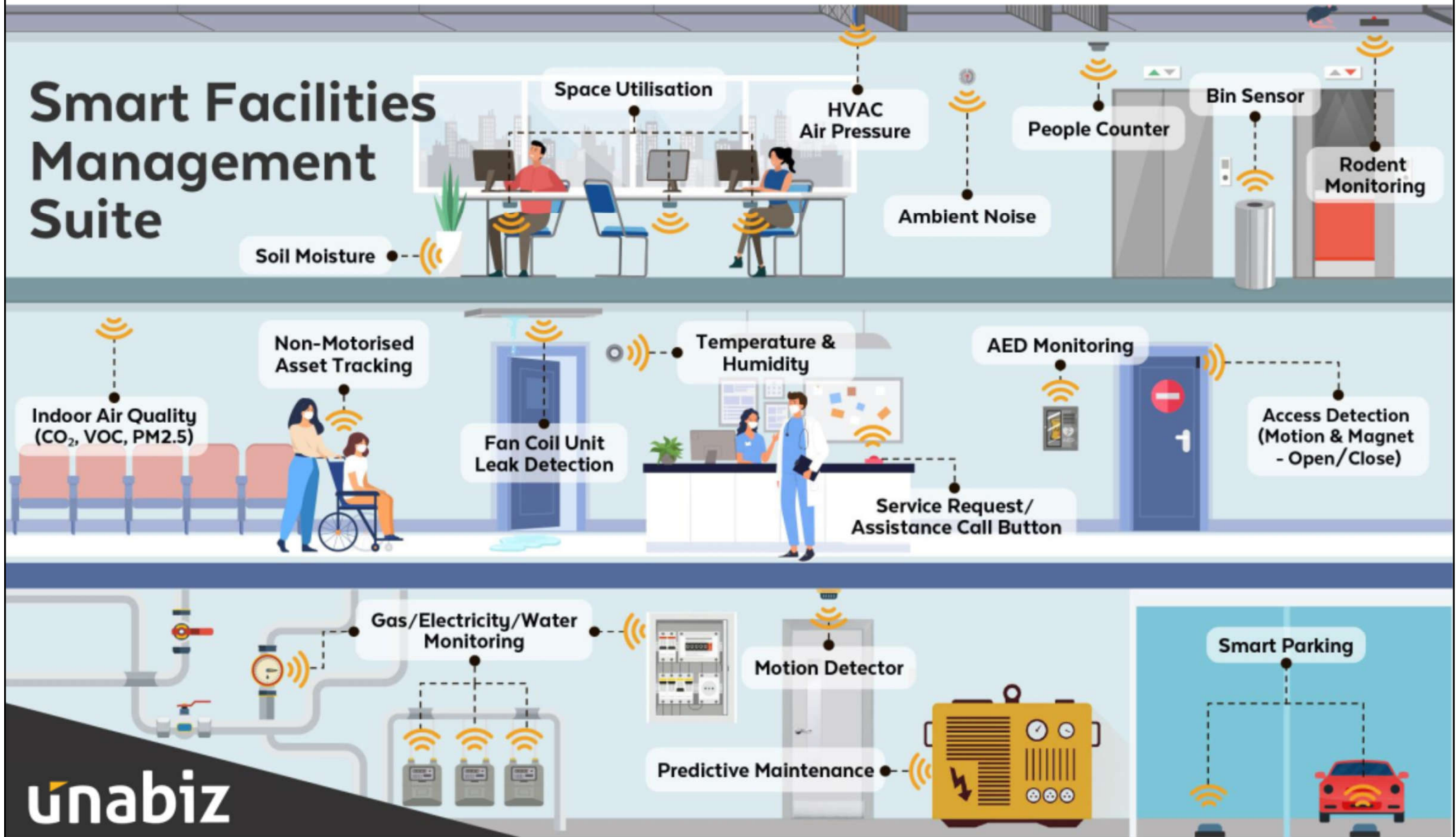


- Major benefits of smart FM:
  - Improve operational efficiency, facilitate workflow automation, resources access & predictive maintenance
  - Keep staff connected in work anywhere, anytime & link them together with media sharing
  - Enhance user experience (minimise downtime, enhance comfort, paperless forms & document)
  - Cost savings (reduce O&M cost, manpower cost)
  - Improve sustainability (optimize resources use)



# Smart facilities management suite

## Smart Facilities Management Suite



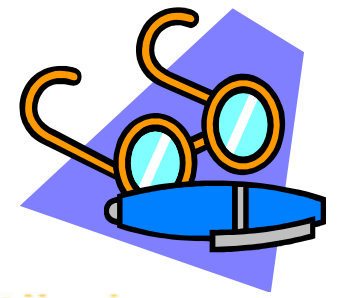
unabiz

# Smart/digital facilities management for office workplace





# Smart FM



- Smart restroom/toilet

- Reduce queuing time for restroom
- Usage analysis for effective cleaning schedule
- Consumable level monitoring for timely replenishment of soap, toilet paper and hand towel
- Ambience monitoring e.g. air quality, restroom odour & wet floor
- Interactive customer survey to gather customer satisfaction index



# Smart toilet system

L2

可使用 Available

0 3

維修中  
Maintenance

空氣質素 Air Quality : 佳 Good

2022/1/01 09:00 am 星期三 Wed 31.8 °c 67.2 %

其他樓層  
Other Floors

L1

可使用  
Available

清潔中  
Cleaning

使用中  
In Use

L3

可使用  
Available

暫無空缺  
No vacancies

可使用  
Available

可使用  
Available

L4

可使用  
Available

可使用  
Available

可使用  
Available



People Counting



Ammonia Sensor



Consumable sensor



Alert System

一樓男洗手間 L1 Men's Toilet

2022/7/20 10:57

星期三 Wed

可使用 Available

5

廁格  
Cubicle(s)

鄰近洗手間 Toilet Nearby

二樓男洗手間

L2 Men's Toilet

4 分鐘  
Minute(s)

1



導航 Navigation



Vacancy indication



Fall detection



Gain Insights

31.8 °c 67.2 %

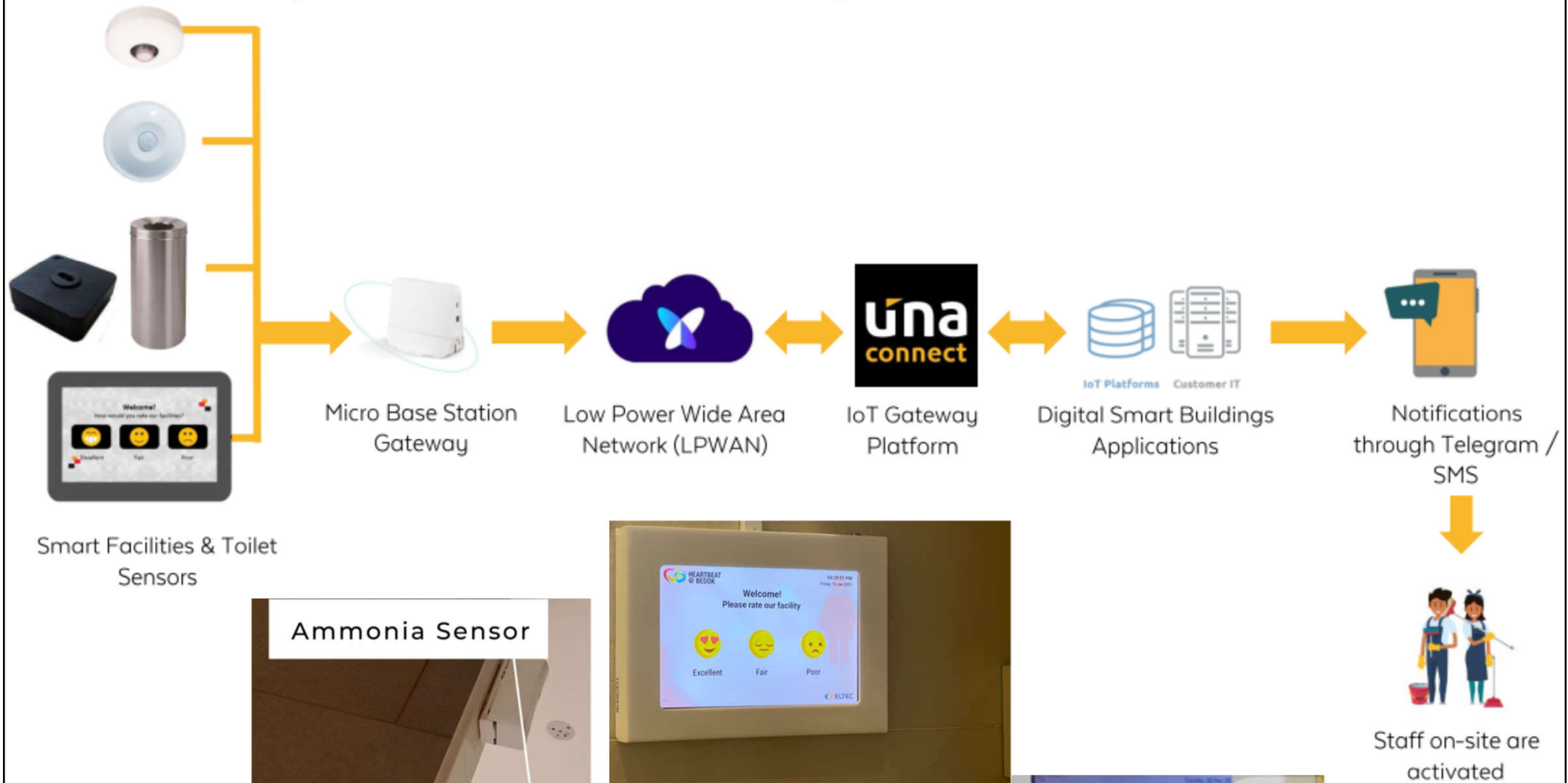
資料來源: 香港天文台  
Source: Hong Kong Observatory



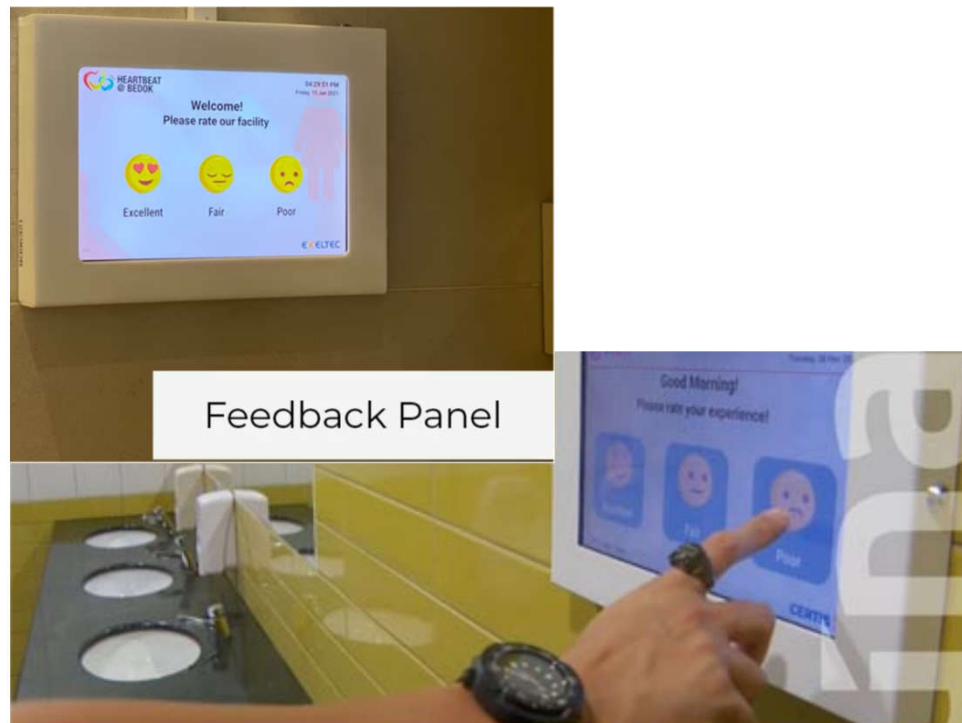
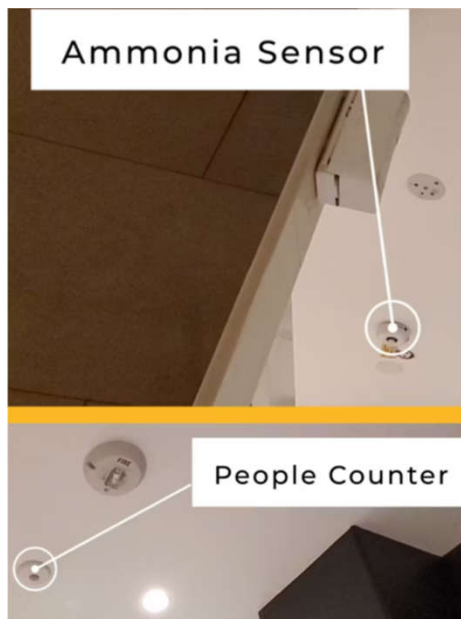
可使用  
Available



# System architecture & components of smart toilet

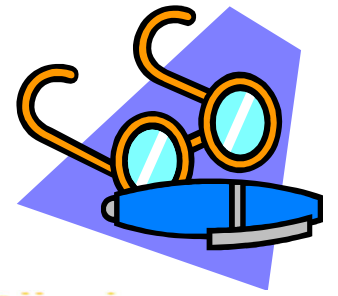


Smart Facilities & Toilet Sensors



(Source: [https://www.unabiz.com/use\\_case/smart-toilet-management/](https://www.unabiz.com/use_case/smart-toilet-management/))

# Smart FM



- Smart parking
  - Reservation service App to reduce queuing time
  - Touchless entry & mobile payment
  - Indoor navigation & find my car mobile App
  - Real-time data insights for better carpark management
  - Support workflow integration for efficient operation, cleaning, maintenance & customer services

# Smart parking system

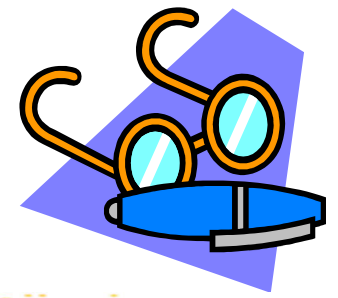


## 數碼智能泊車體驗

一App在手 進出新城市廣場更悠遊

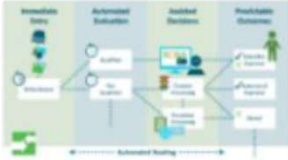
















- 於手機應用程式上載即日消費單據換領免費泊車  
同時亦可用 The Point 積分換領
- 免觸式泊車服務
- 無感泊車支付功能

# Key factors



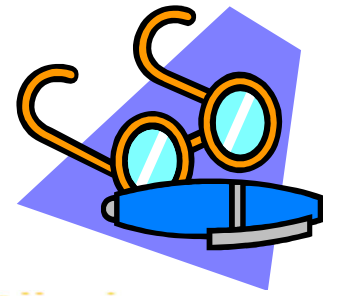
- Drivers of smart facilities management:
  - 1. Internet of Things (IoT) & radio frequency identification (RFID)
  - 2. High-speed, high bandwidth wireless networks
  - 3. Artificial Intelligence (AI) & data analytics
  - 4. Augmented & virtual reality (AR/VR) visualization + Digital twin (DT)
  - 5. Intelligent video & image analysis
  - 6. Drones (e.g. inspect building façade & rooftop)

# A smart FM framework with multiple solutions identified

Type/ Scope	Description	Building Level FM Services				Clustering	
		Energy	Security	M&E Functions	Environmental Services		
<b>Type 1</b> Digitalised Workflow Automation	When triggered, by an incident, automatically initiates a process that track, log, and close the incident	 Workflow Automation System				 Towards Aggregation	 Mixed Developments
		 EPC Remote Monitor BCA Portal	 Video Monitoring with Incident Detection	 Lift Monitoring	 Toilet Sensors, Compactor		
<b>Type 2</b> Optimisation within System	Use data analytics to <ul style="list-style-type: none"> <li>- Optimize systems</li> <li>- Quantify FM efficiency</li> <li>- Perform Preventive/ Predictive maintenance</li> </ul>	 Connected Services for Chiller Optimization	 Security Kiosk and Occupants Engagement	 Failure Prediction	 Usage and Feedback data to optimize cleaning		 Portfolio of Buildings
		 Connected Lighting Systems, with temperature/RH and occupancy sensor	 Rodent Surveillance		 District Level		
<b>Type 3</b> Integration Across Systems	Optimize resource deployment and utilisation across many systems	 Co-sharing or Hot Desk Integrating Booking, Billing, Security, Space Management, Thermal Comfort	 Integration of systems for Demand/Occupant-based building control & optimisation				



# Key factors



- How to apply smart facilities management?
  - Integrate digital technologies & smart automation into facility operations & maintenance to optimise efficiency & performance
  - Consider carefully staffing, budget, training, equipment, procurement (in-house or outsource)
- Technology application
  - Integrate technologies into business operations of the organisation to optimise efficiency & effectiveness of processes

# Five steps for the adoption of smart facilities management



## STEP 1

**S**et business objectives and outcomes

## STEP 2

**M**ap out smart FM solutions as enablers

## STEP 3

**A**dopt suitable implementation model

## STEP 4

**R**eview procurement contract

## STEP 5

**T**rack outcomes and review for continuous improvement



A 5-step SMART process towards:



Improving reliability, productivity and service

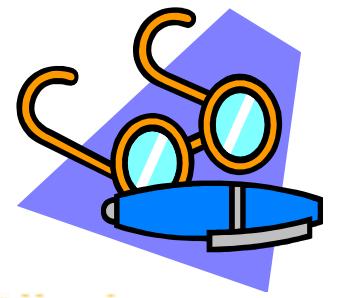


Integrating systems, processes, technologies and personnel



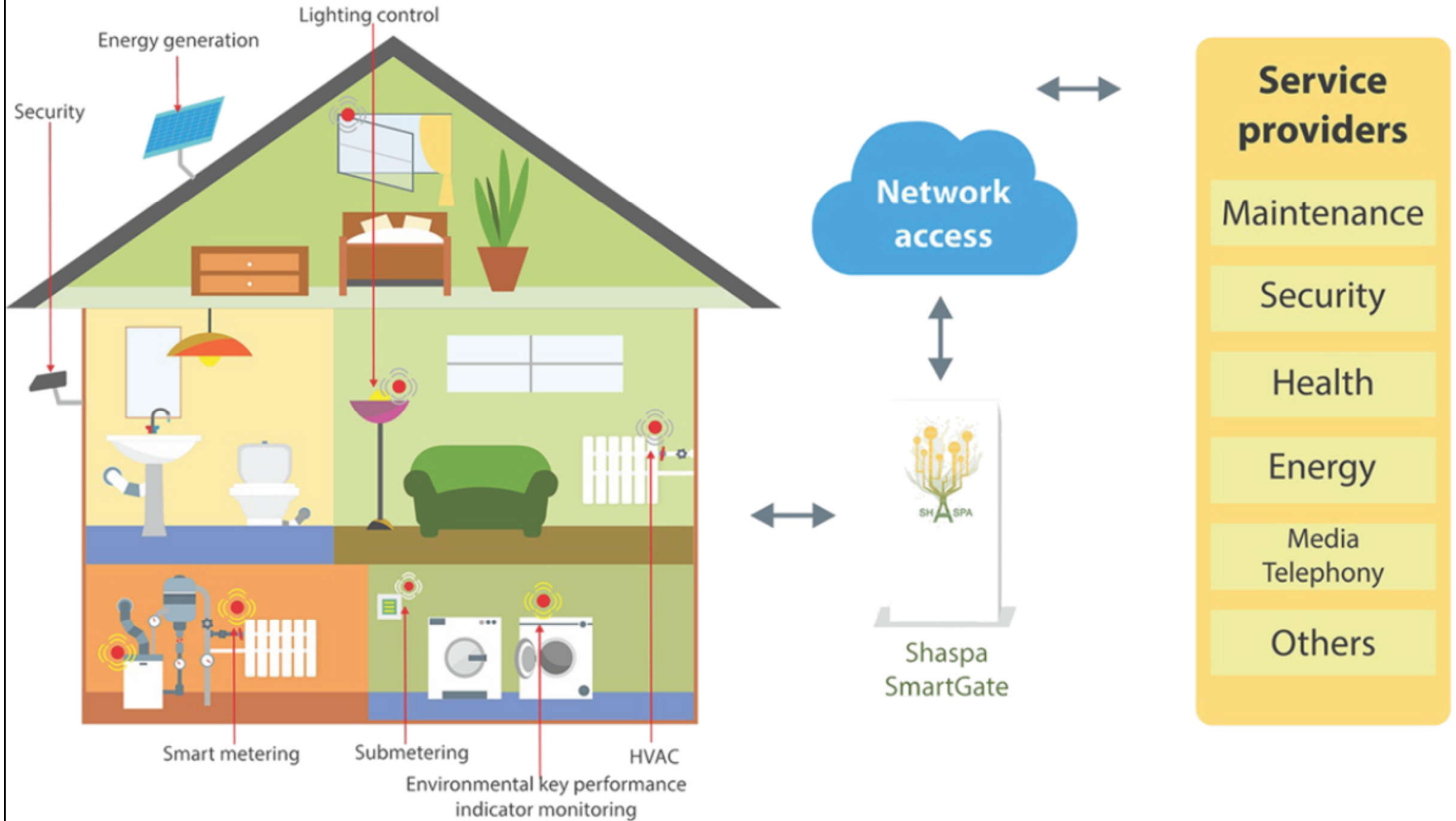
Future proofing your building's systems

# Key factors

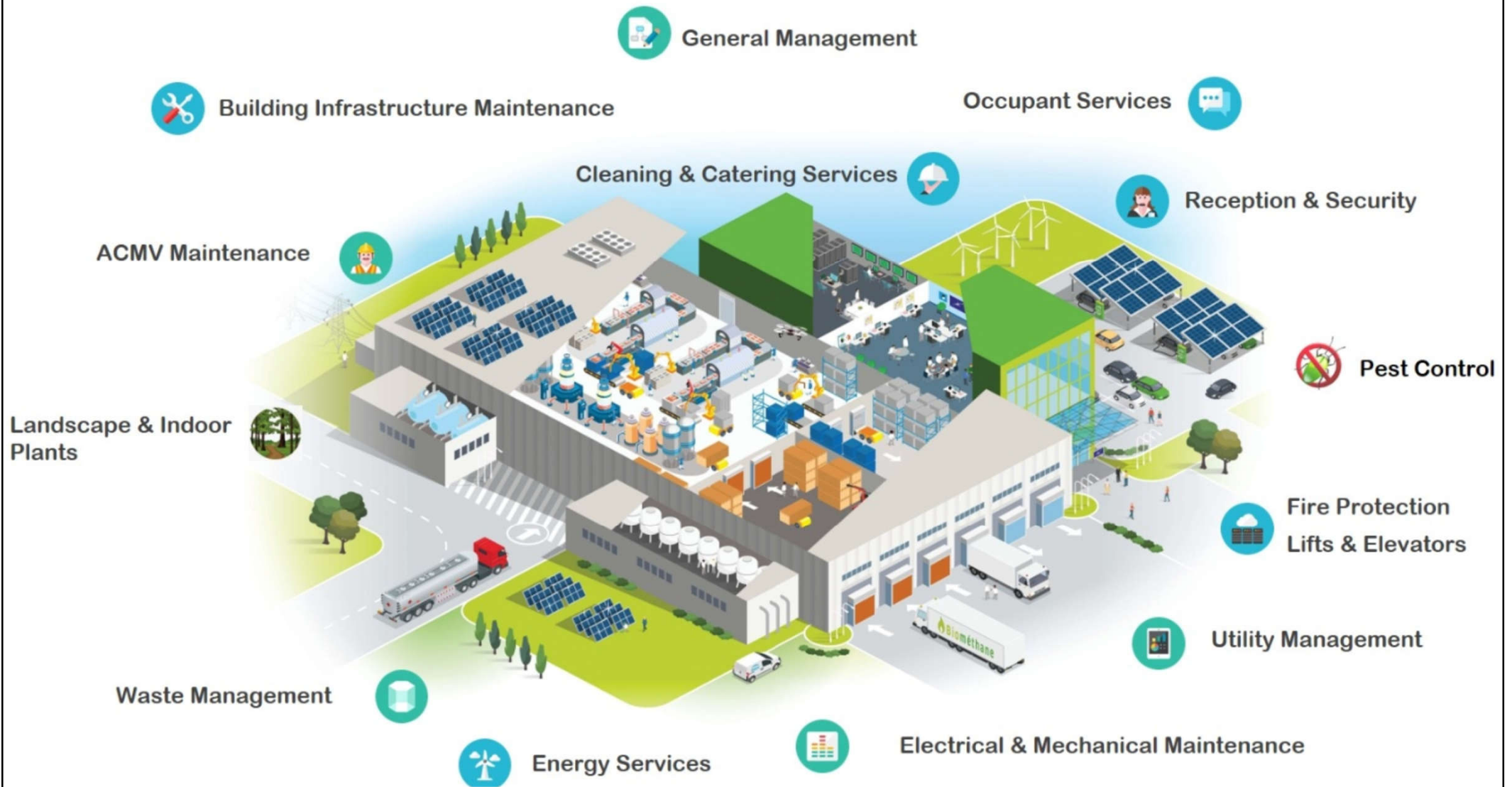


- Applications integration
  - Integrate data or functions from one application with that of another application
  - Involves development of an integration plan, programming & the identification & utilisation of appropriate middleware to optimise the connectivity & performance of disparate applications across target environments
- Manage facility operations & maintenance in an interactive & automated way

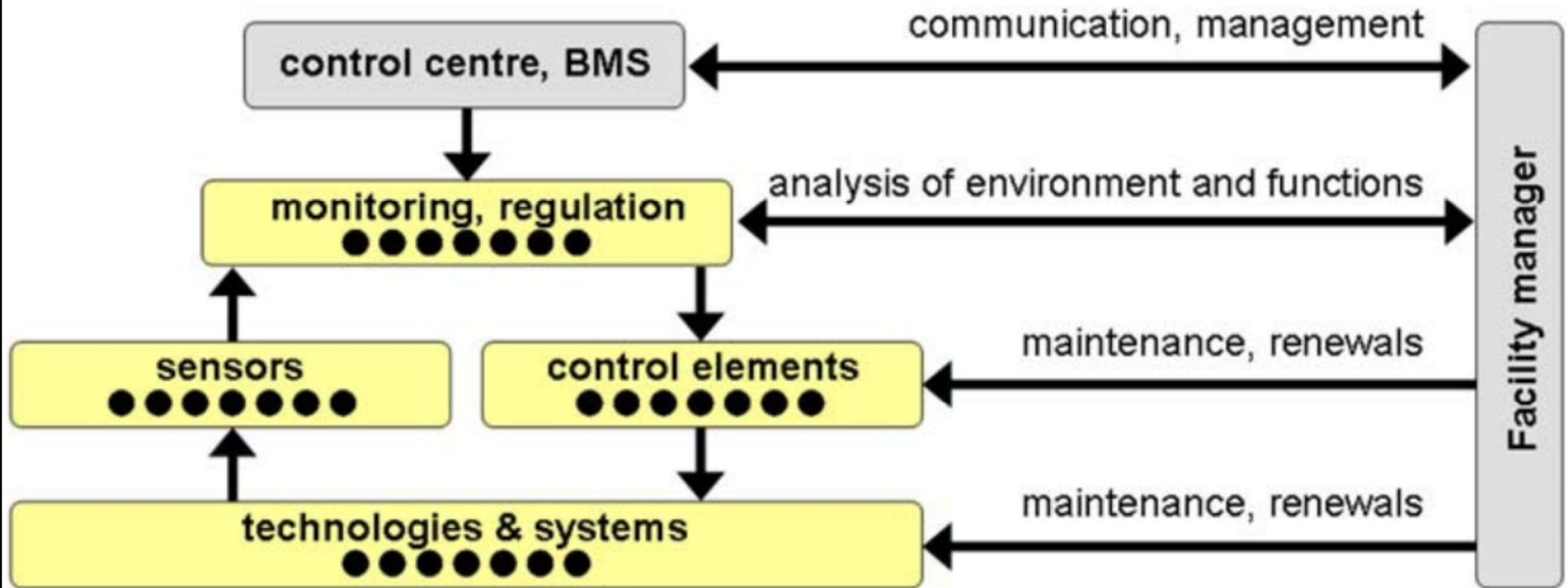
# Integrated equipment & appliances for residential buildings



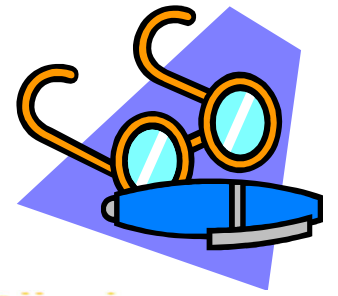
# Integrated facilities management for industrial buildings



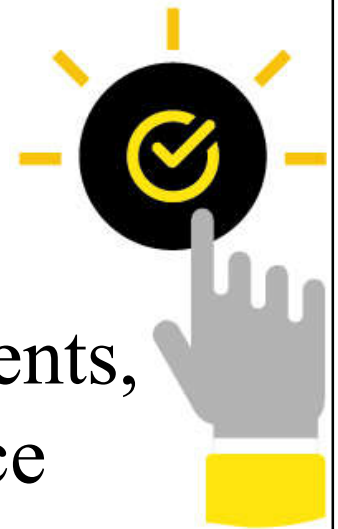
# Function principle of building management system (BMS) in relation to performance of facility management



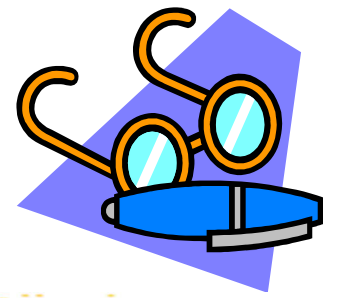
# Key factors



- How to enhance operation efficiency & manpower management in smart FM?
  - Workflow automation tailored for FM
  - Easy management & control of task assignments, work orders, patrols & scheduled maintenance integrated in one platform
  - Utilize manpower resources & mitigate faults
  - Timely reporting of incidents, job dispatch, work progress, task completion & errors



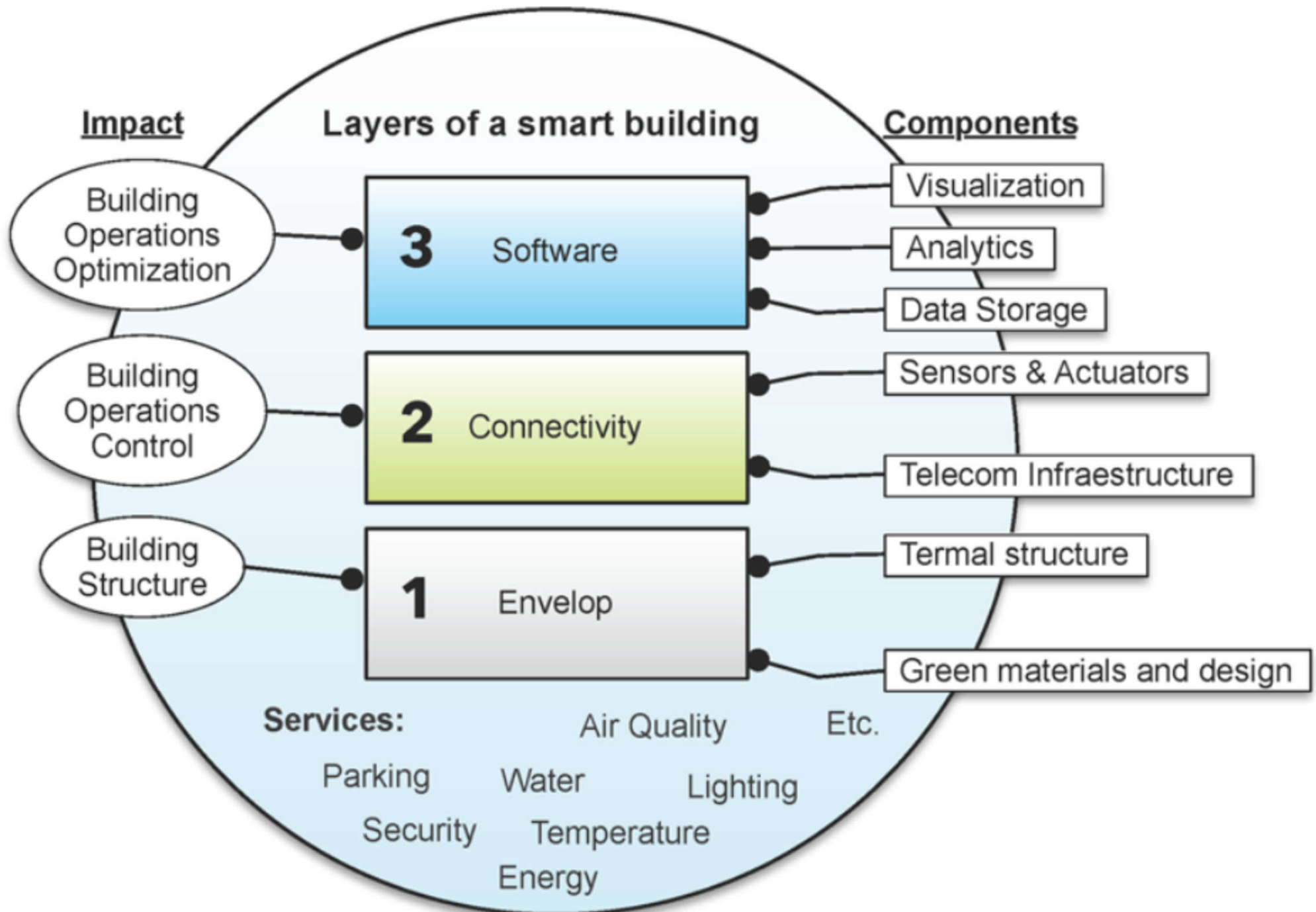
# Key factors



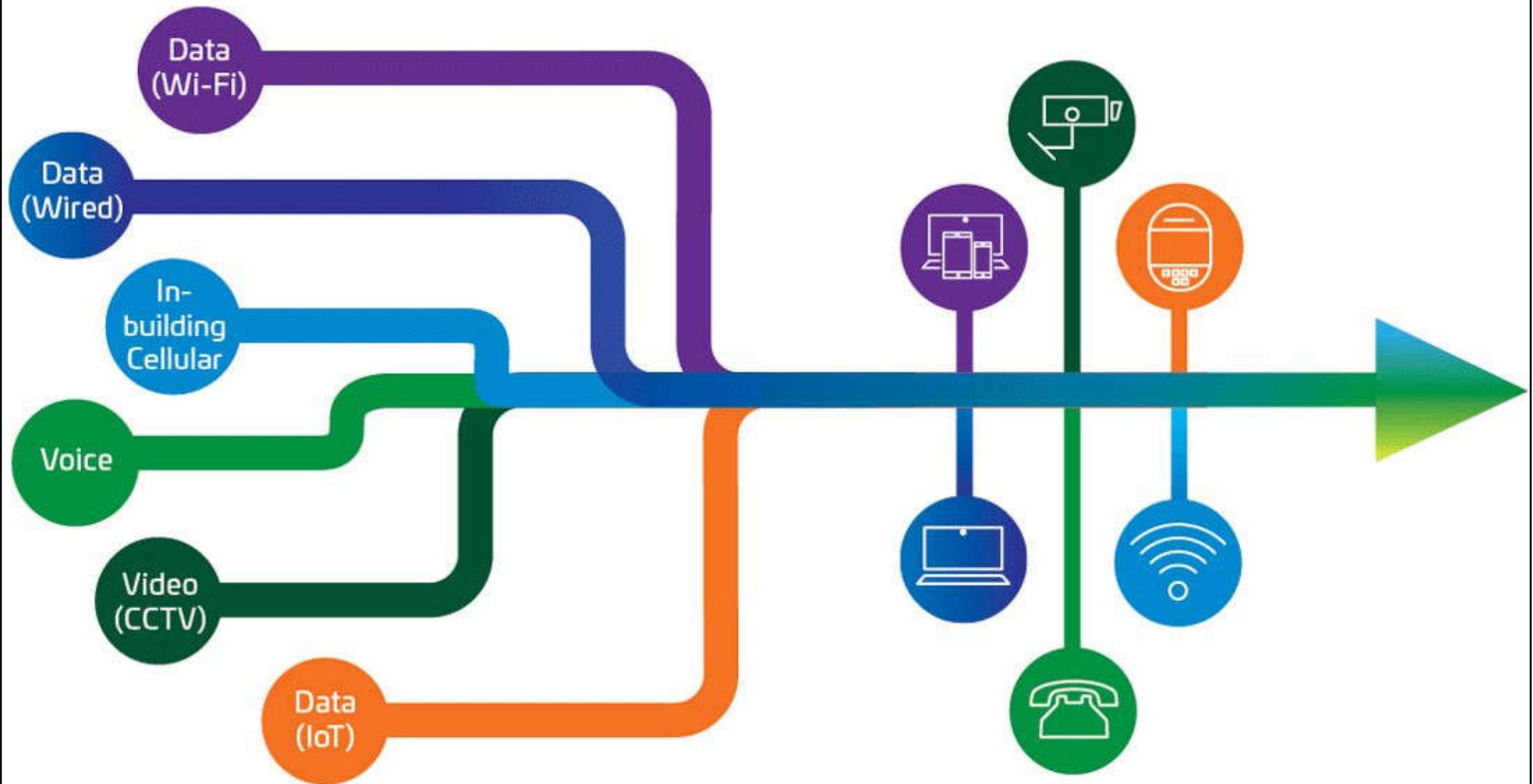
- Tips for creating a smart building
  - 1. Define & set clear goals
    - Clearly establish the objectives & desired outcomes
  - 2. Prioritize data security
    - Implement strong security measures to ensure safety
  - 3. Collaborate with stakeholders
    - Work with stakeholders & occupants effectively
  - 4. Embrace sustainability
    - Enhance energy efficiency & sustainability
  - 5. Build a reliable network infrastructure



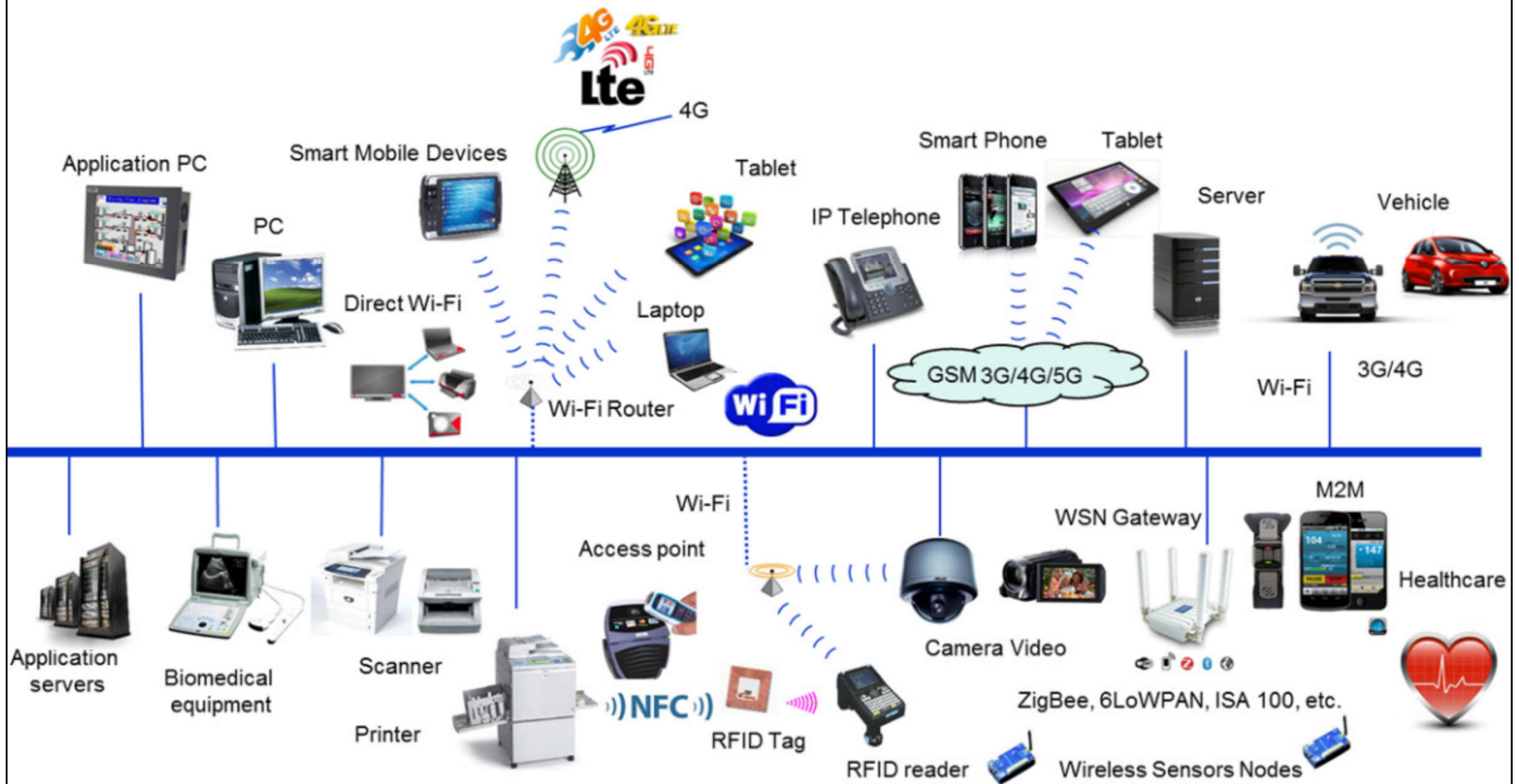
# Three layers of a smart building



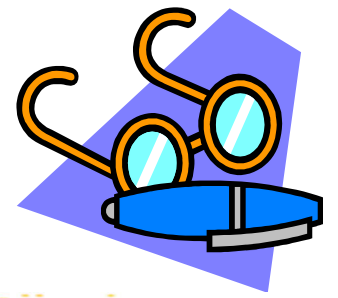
# Converged networks inside the building



# Network convergence using Internet Protocol (IP)

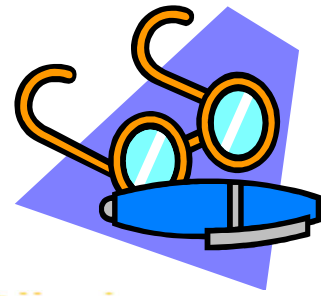


# Key factors



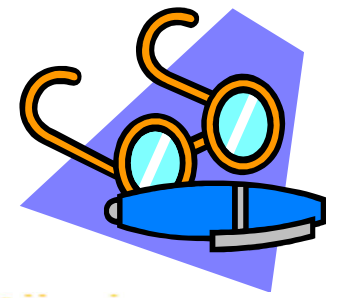
- Key considerations in managing data:
  - 1. Avoid data silos (fragmented standalone solutions) & ensure data interconnectivity
  - 2. Ensure interoperability & avoid smart solutions that are not portable but tied to specific vendor
  - 3. Balance cybersecurity & implementation efficiency
  - 4. Combination of workflow & information storage solutions to support information management process for the asset

# Key factors



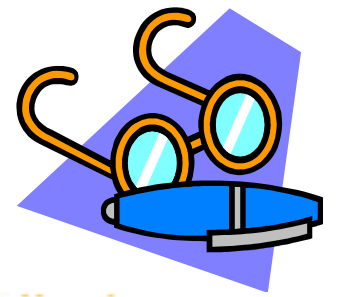
- Common features for FM data management:
  - Manage file & data (data standards & hierarchy)
  - User management (access right & services)
  - Dashboard, analytics & reporting
  - Operation & workflow management
  - Open protocols (ensure ease of interconnectivity)
  - Cloud-based environment (allow data & information to be efficiently accessed, shared & maintained from any location)

# Key factors



- Examples of essential FM functions:
  - 1. Workflow tracking & service level delivery
    - Consolidation & analysis of data pertaining to works detected & carried out within a building or multiple buildings
  - 2. Fault detection & diagnostics (FDD)
    - Detecting deviations from normal or expected operation (faults) & diagnosing the type of problem & its location
  - 3. Condition-based maintenance
    - A predictive maintenance strategy where various elements of an operating asset are observed & measured over time to identify potential failure before it happens

# Smart space management



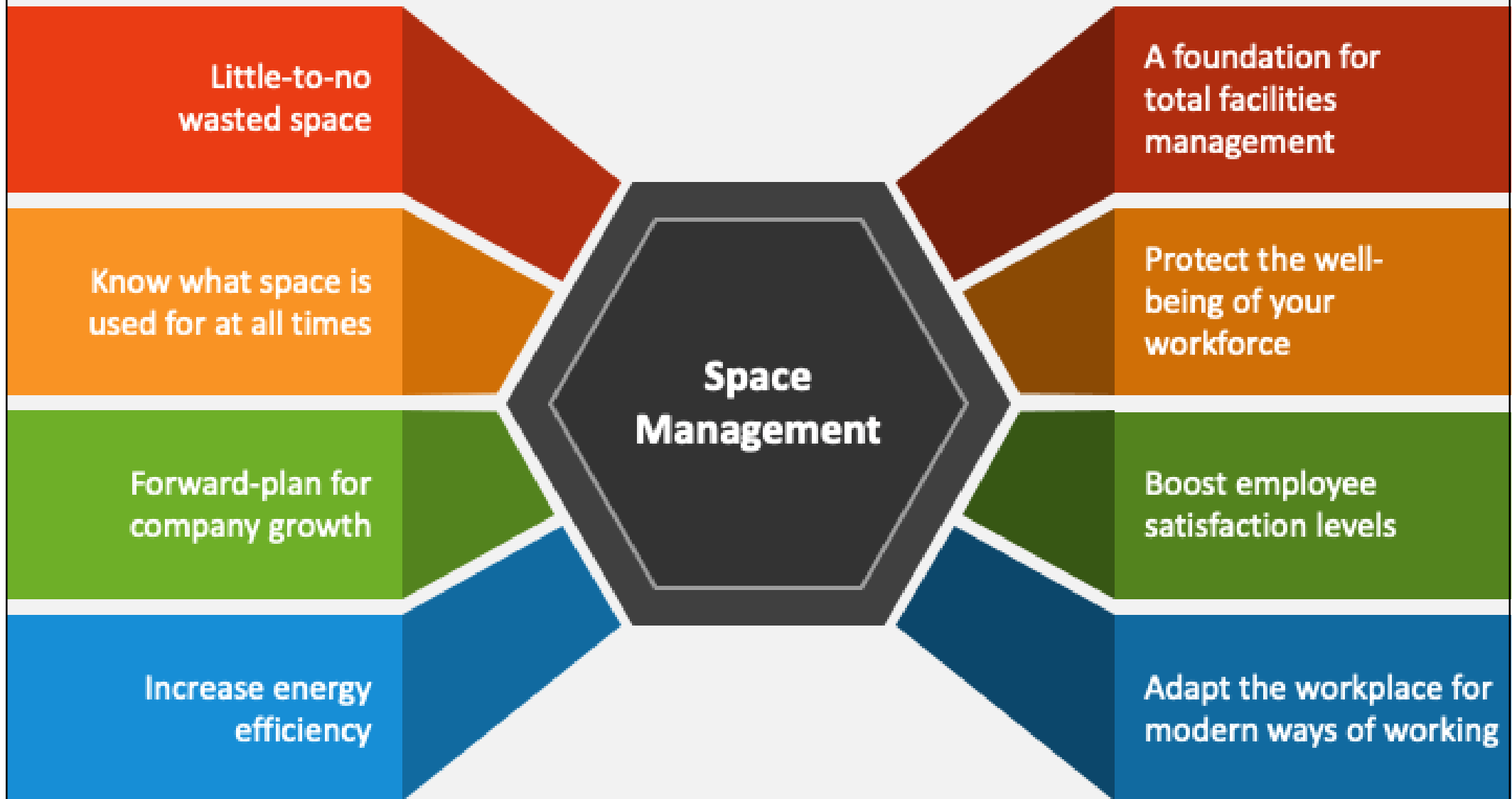
- Smart spaces (or connected spaces)
  - Workspaces within smart buildings that use technology & ambient intelligence to allow for monitoring & measurement of occupancy levels, available vacancies, use of amenities, etc.
  - Designed for optimal use & triggered by sensors & intelligent devices (e.g. smart watches, mobile devices & handheld badges) for the identification of office workers, their status & their relationship with office spaces

# Objectives of space management

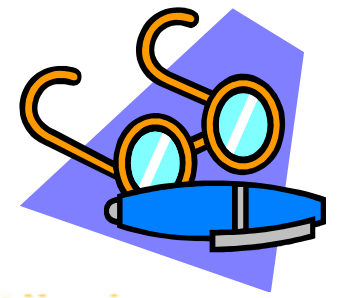
Objective	Explanation
Functionality	To ensure organization functionality is suitable with optimization of building space.
Consistency	To ensure space management is carried out consistently and systematically in achieving organizational objectives.
Efficiency	To ensure space being efficient, in good control, and bring maximum profits to the organization.
Flexibility	Even though space management requires control over space usage, the element of flexibility is not ignored, such as when there is an expansion of staff or staff reduction.
Cost	Effective space management, which has considered planning, execution, and monitoring elements, will decrease overall cost reduction and maintenance cost.



# Benefits of space management

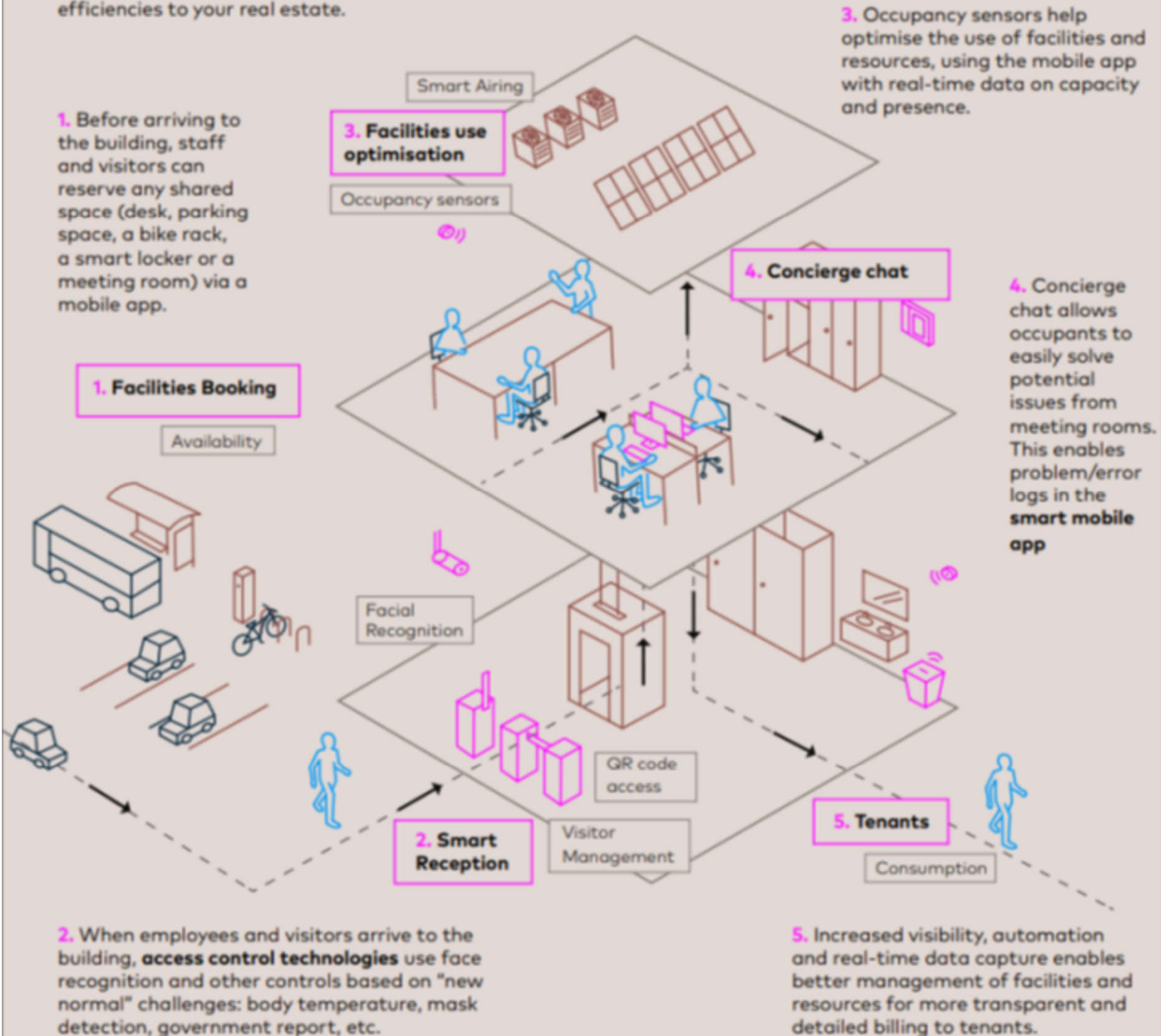


# Smart space management



- New business models in office space usage, e.g. **Space-as-a-Service (SaaS)**
- Better utilization of spaces, as well as ensuring workers' well-being
- Productive workplace & engaging work environment
  - Improve functionality & efficiency of the space
- Provide flexibility & capabilities to quickly adapt to constantly evolving environments

Smart buildings can delight your building occupants, keep them safe, and bring financial and operational efficiencies to your real estate.

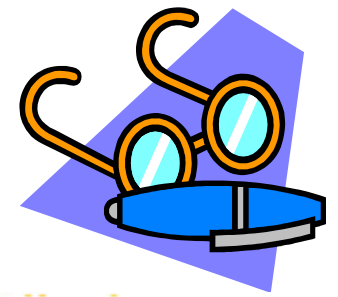


## The smart space journey

# Smart space applications for workspaces, retail, healthcare & manufacturing buildings

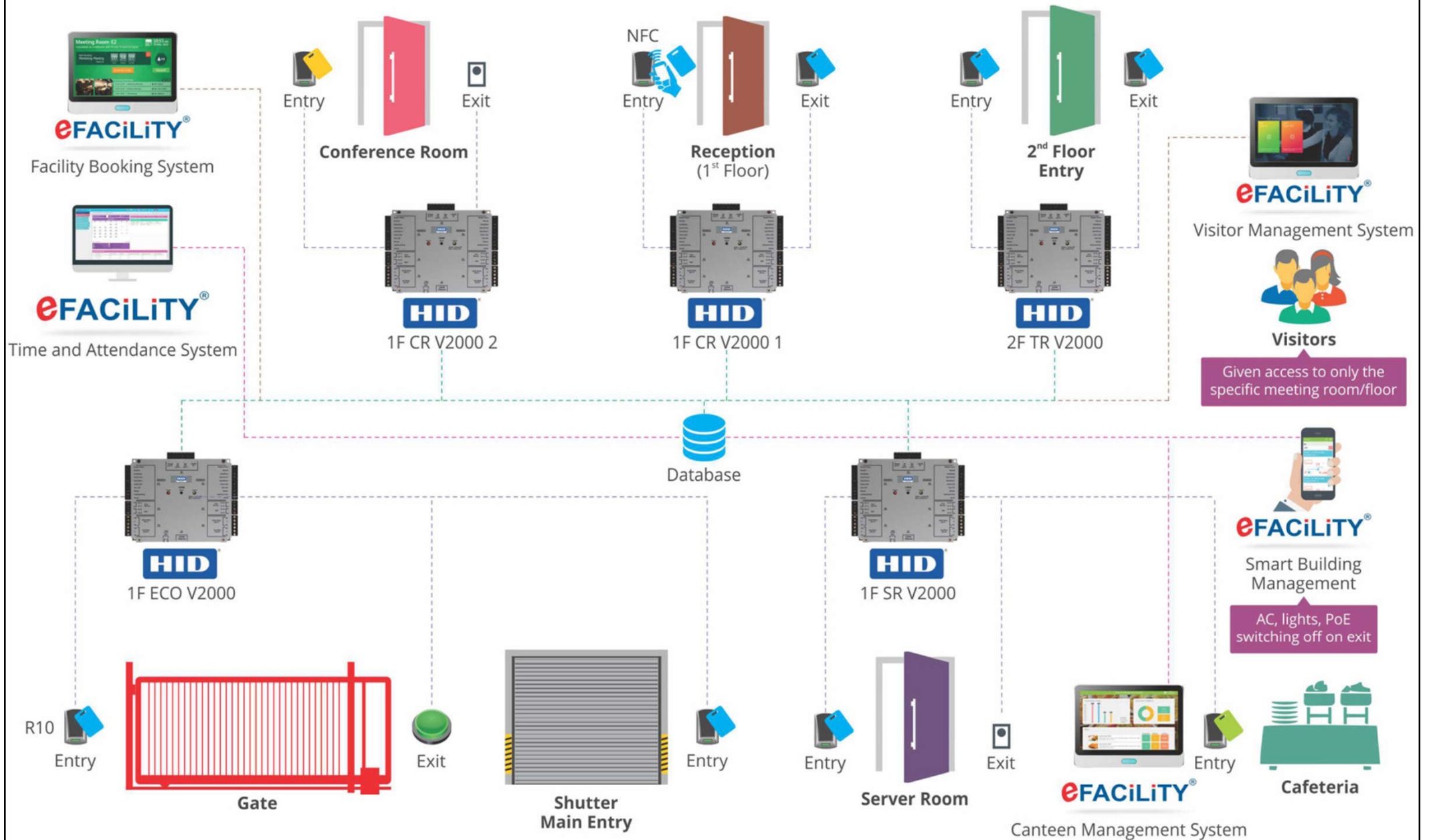


# Smart space management

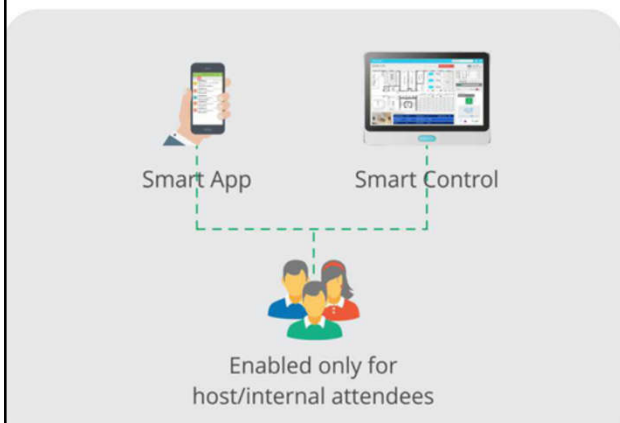
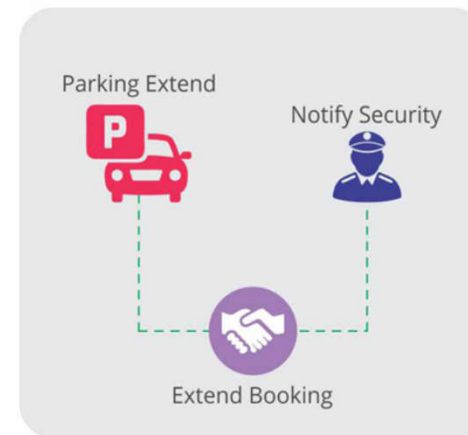
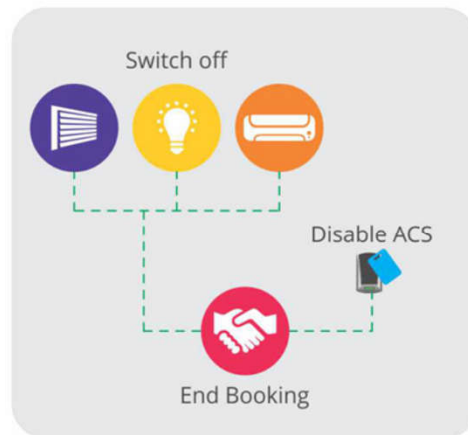
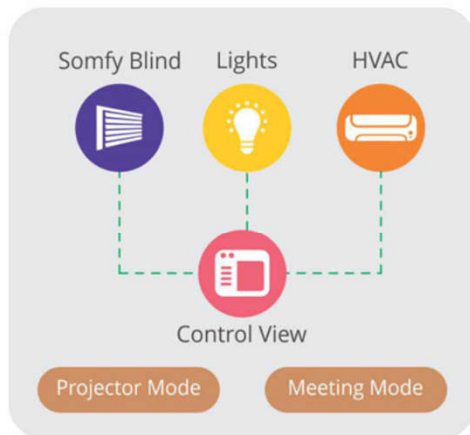
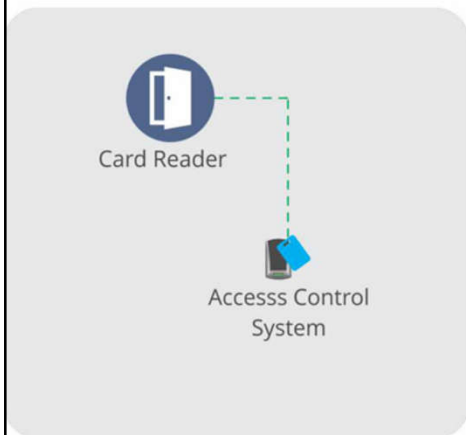
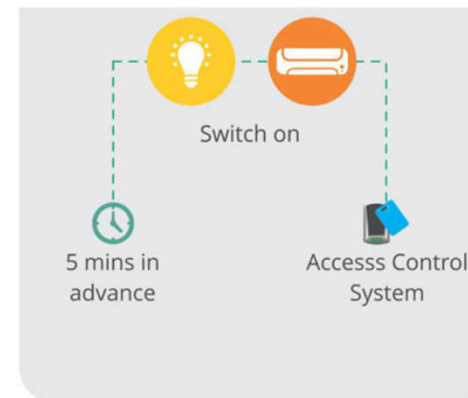
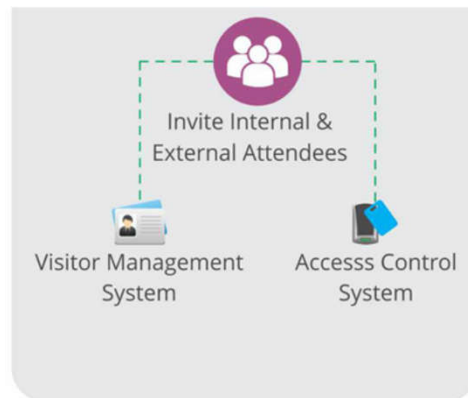
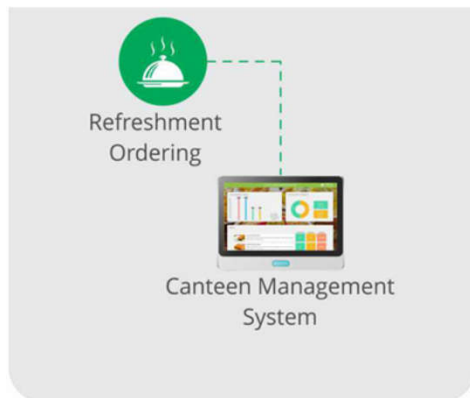
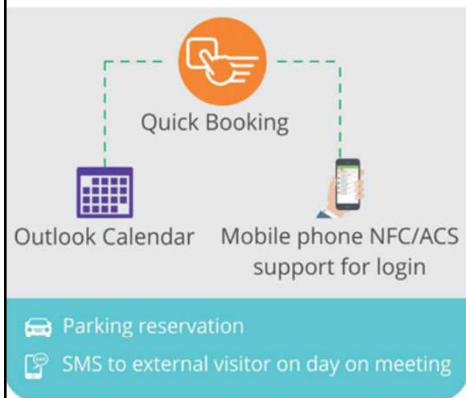


- Smart space components:
  - 1. Smart access control (e.g. facial recognition, contactless access, body temperature check)
  - 2. Facilities booking (with reports on usage)
  - 3. Spaces management (flexible schedule/services)
  - 4. Visitor management (register guest remotely)
  - 5. Occupancy monitoring (numbers & location)
  - 6. Smart HVAC (improve indoor air quality)
  - 7. Energy use monitor (facilitate O&M)

# Access control integration of smart buildings



# Facility booking system with conference room control functions



## Integrated With:



- Facility Booking System
- Building Automation System
- Smart Building App
- Canteen Management System
- Visitor Management System

## Highlights:

- Fully automated operations providing excellent user comfort
- Restricted access to boardrooms & conference rooms and improved overall security
- Reduces power wastage
- Everything at the touch of a button reducing dependence on manpower
- Integration with all relevant systems resulting in seamless operation

# Visitor management system



**Integrated With eFACILITY®**

- Facility Booking System
- Card Management System
- Canteen Management System
- Access Control System
- Feedback / Suggestion Management System

**Devices Integrated**

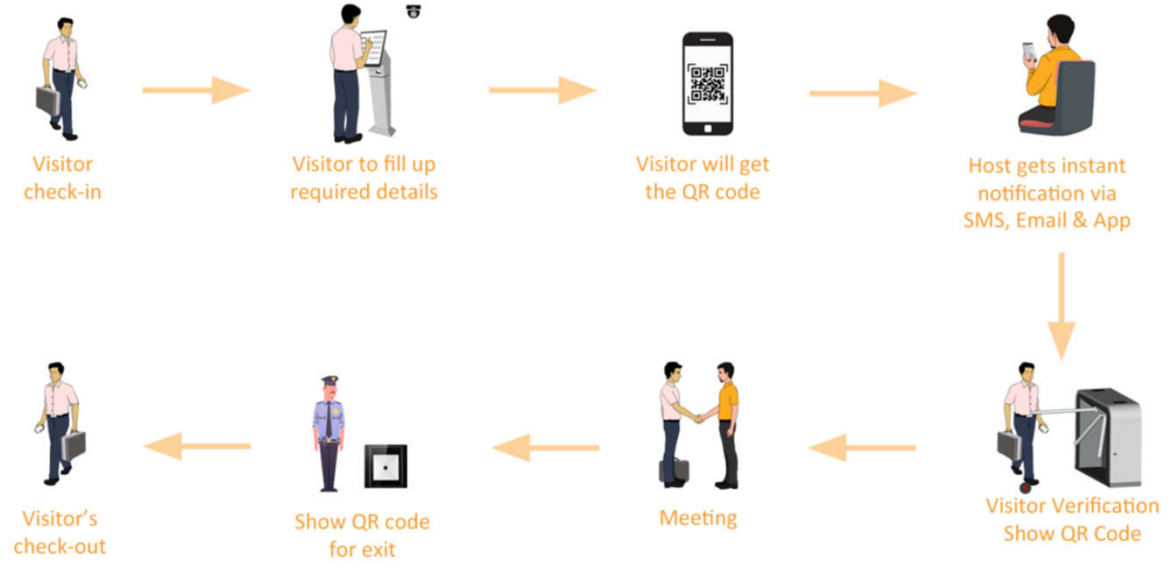
- Web Camera
- Signature Pad Device
- Business Card Reader
- National ID Card Reader
- Printers
- Scanners
- Access Control System - Turnstile, Boom Barrier etc.

**Emergency SMS Alert to all Visitors**

- Fire Alarm system
- Security

**Sign-out Process**

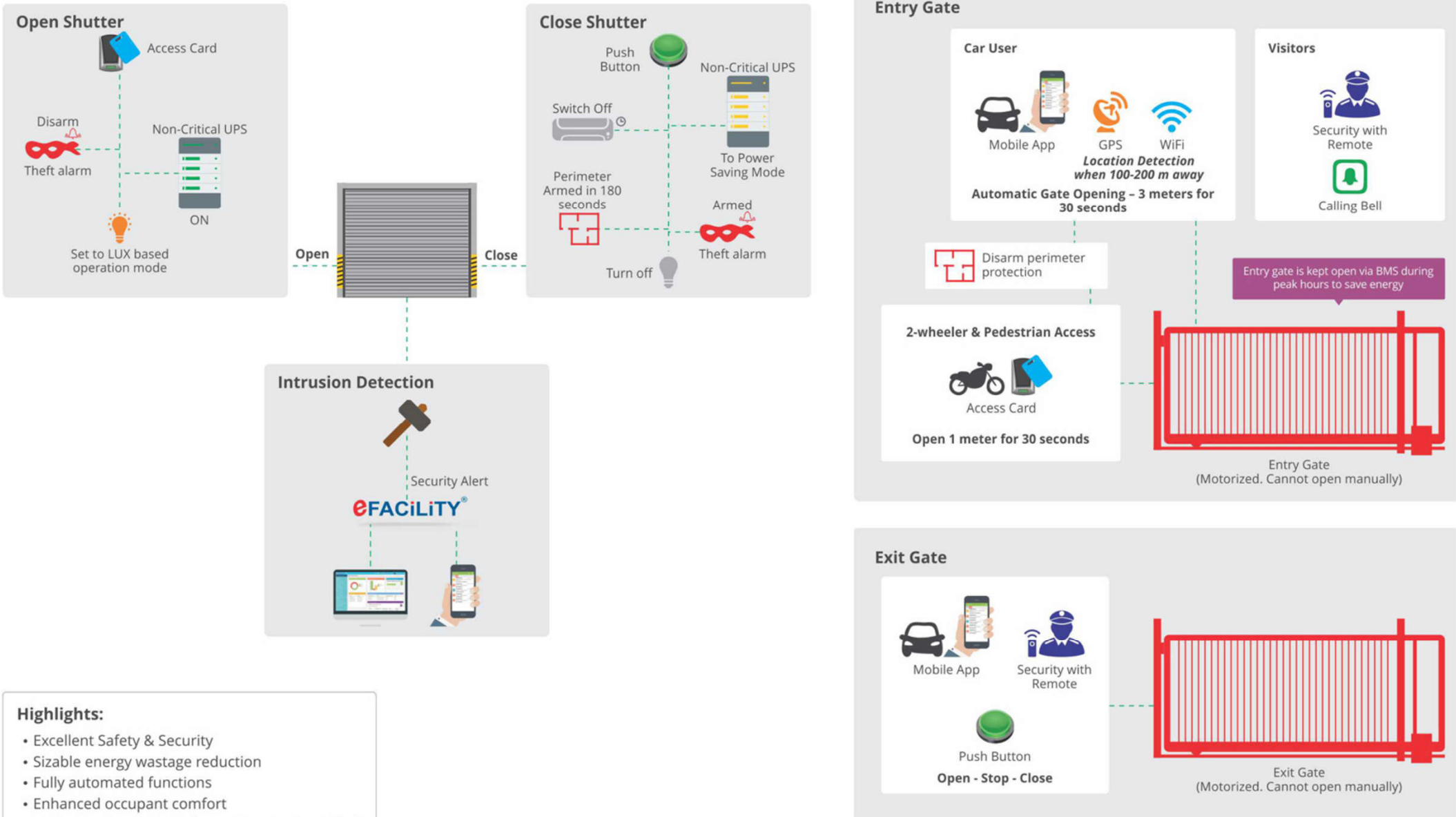
- Visitor Sign-Out
- Feedback Management System Integration
- Enters Feedback
- Exits the Premises



(Source: <https://www.greenestbuilding.com/smart-building/visitor-management/>)



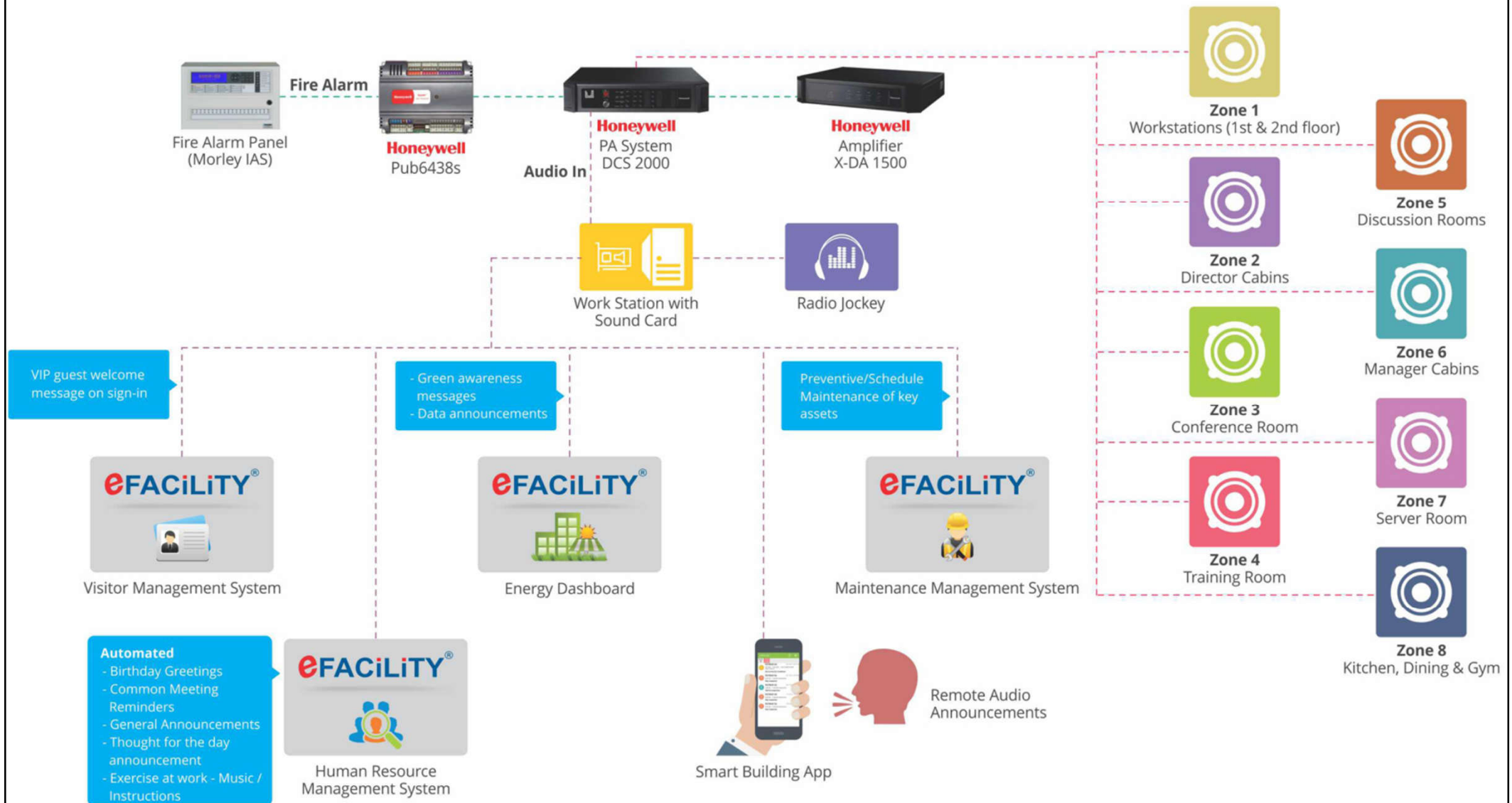
# Automated gate & shutter system



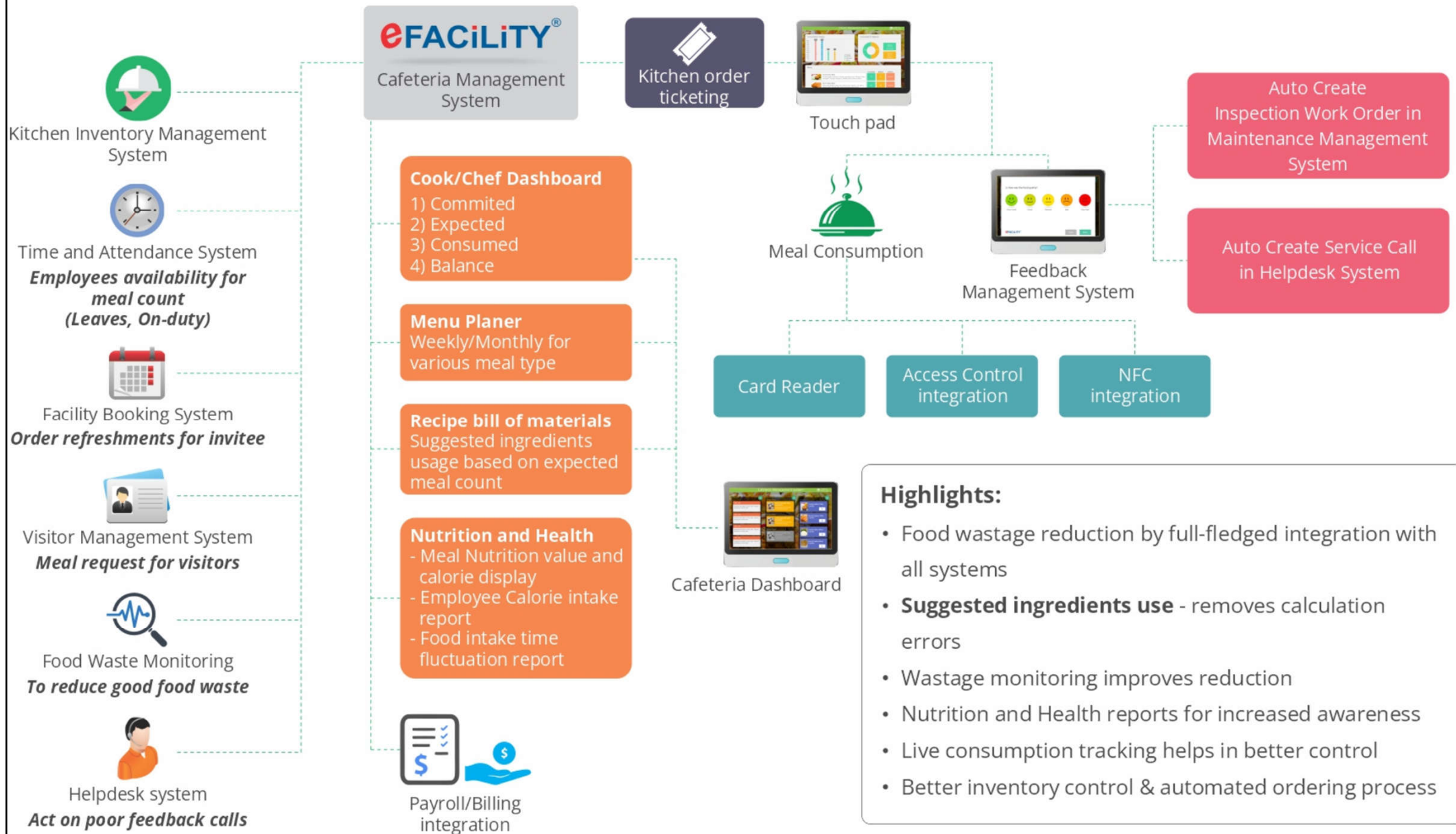
## Highlights:

- Excellent Safety & Security
- Sizable energy wastage reduction
- Fully automated functions
- Enhanced occupant comfort
- Reduction in number of security guards needed

# Public address (PA) system integrated with fire alarm, visitor management, human resources management, energy dashboard & maintenance management



# Cafeteria management system



# Business cases for space management in smart buildings

Optimize Space  
Planning & Utilization

Enhance Energy  
Efficiency

Improve Employee  
Experience

Streamline  
Maintenance Effort



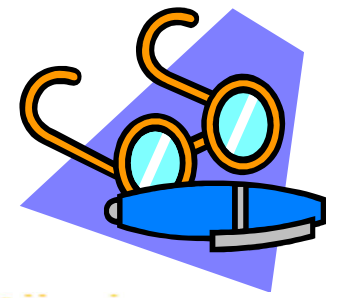
- Make strategic decisions on office layouts & amenities
- Optimal mix between open, co-working areas & individual zones to foster collaboration, innovation & productivity
- Effective allocation of office resources & flexible seating

- Monitor occupancy & corresponding energy usage to streamline consumption & maximize efficiency
- Achieve HVAC energy conservation by tracking workspace utilization

- Occupancy sensing to assist employee in day-to-day work to augment productivity & satisfaction
- Notify when a meeting room is booked & left empty, or whether the cafeteria is currently overcrowded

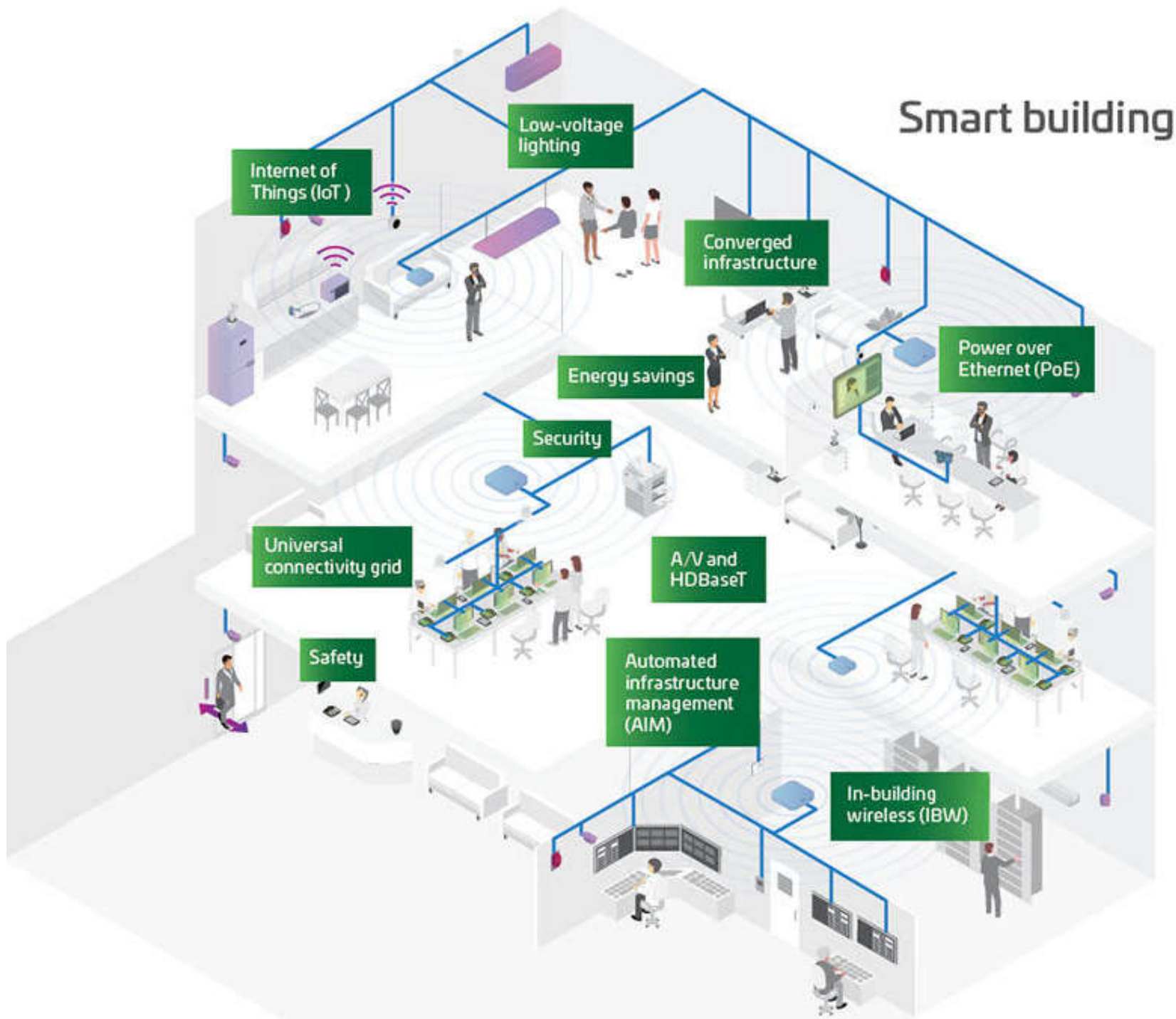
- Knowing the utilization patterns of different office zones allow facility managers to schedule demand-based cleaning activities
- By aligning priority & cleaning frequency with the traffic of each space, managers can ensure proper sanitation is maintained

# Smart space management



- Typical features of smart spaces
  - Convergent network, single, unified IP over Ethernet physical network layer
  - Integrated, IP-based space management systems
  - Automated infrastructure management (AIM)
  - Future-ready infrastructure able to support Internet of Things (IoT) applications & devices
  - In-building cellular & wireless network coverage
  - Integrated power & connectivity systems
  - Power over Ethernet (PoE)

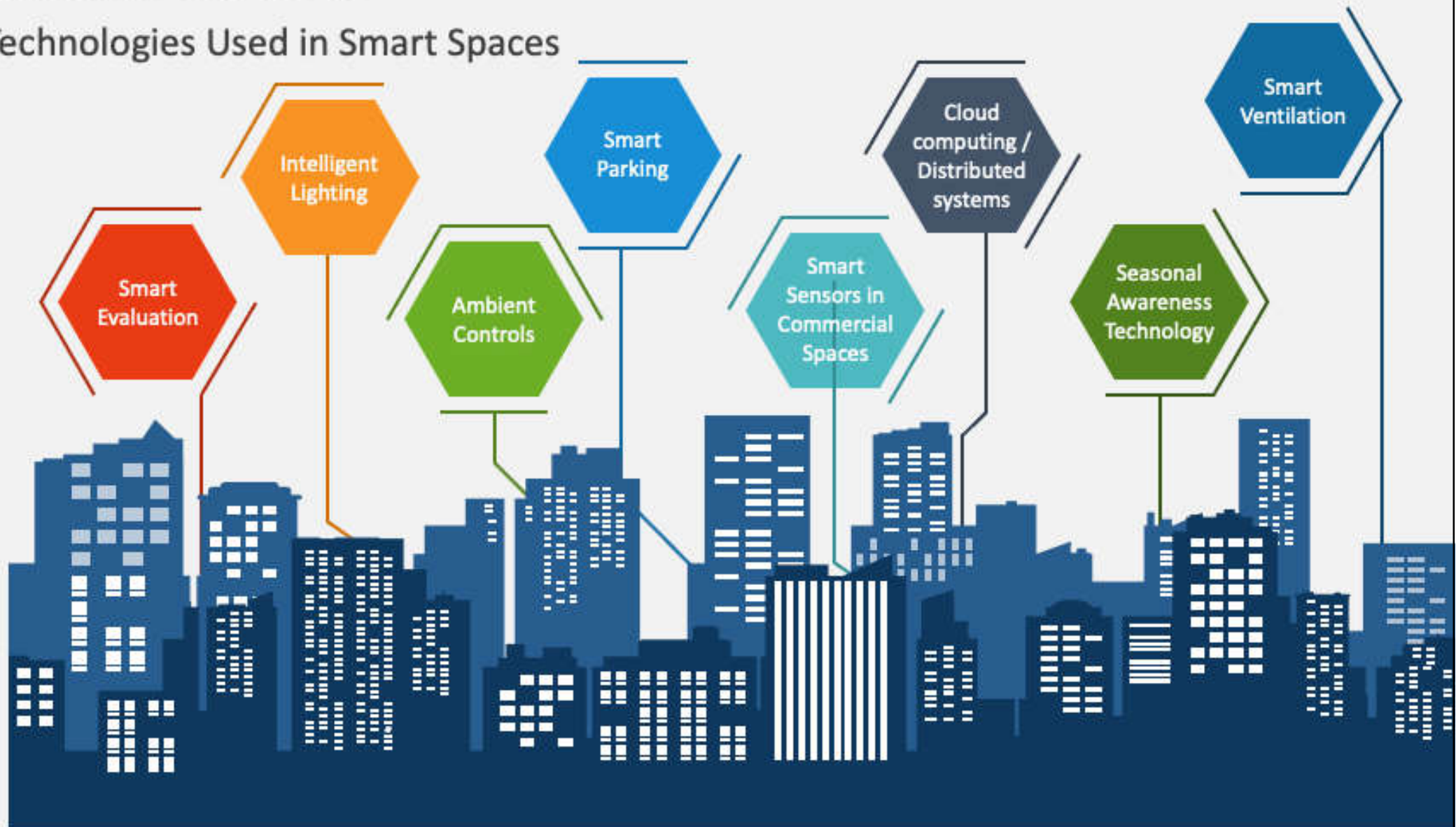
# Features of smart building to support smart space management



# Technologies used in smart spaces

## SMART SPACES

### Technologies Used in Smart Spaces



# How technologies will change the next gen workplaces?





# Smart space evolution

	Isolated	Connected Systems	Coordinated Systems	Intelligent Environment
1   Openness	Closed	Open	Open	Open
2   Connectedness	Not Connected	Connected	Connected	Connected
3   Coordination	Not Coordinated	Integrated	Coordinated	Coordinated
4   Intelligence	Not Intelligent	Not Intelligent	Pockets of Artificial Intelligence	Broad Artificial Intelligence Use
5   Scope	Team	Department	Organization	Ecosystems



# Further reading

- Complete Guide to Facilities Management  
<https://limblecmms.com/blog/facilities-management/>
- How IoT Reinvents Space Management in Smart Buildings  
<https://behrtech.com/blog/how-iot-reinvents-space-management-in-smart-buildings/>
- Smart Facilities Management (FM)  
<https://www1.bca.gov.sg/buildsg/facilities-management-fm/smart-facilities-management-fm>
- Smart spaces: enhanced, connected urban environments of tomorrow  
<https://www.commscope.com/insights/the-enterprise-source/smart-spaces-the-fact-file/>