MECH 1905 Buildings for Contemporary Living Intelligent/Smart Building

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Outline

- Introduction
- Definitions and Objectives of Intelligent Buildings
- Intelligent Building Characteristics
- Difference between Ordinary Buildings and Intelligent Buildings
- Intelligent Building Systems
- Intelligent Buildings and Green Buildings

Intelligent Buildings

An intelligent building is designed and constructed based on an appropriate selection of quality environment modules to meet users' requirements by matching the appropriate building facilities to achieve long-termed building value.

What is an Intelligent Building?

GOVERNMENT · OFFICE BLDG. · INDUSTRIAL · HOSPITALITY · HEALTHCARE · EDUCATION · RETAIL · MULTI-HOUSING · MUSEUMS
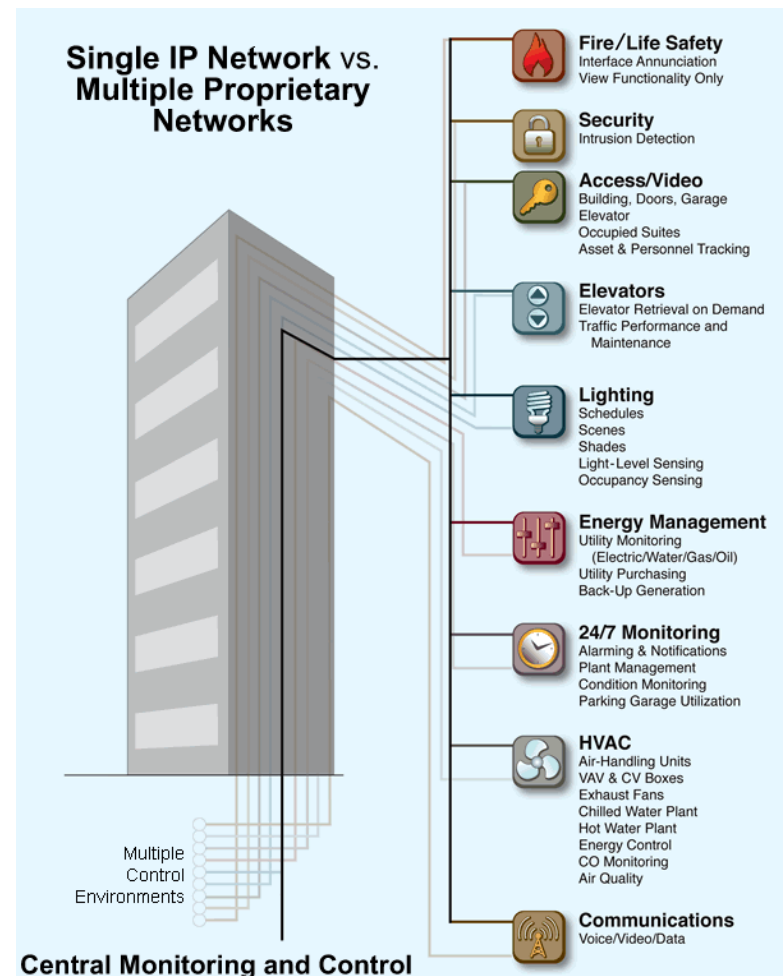
Intelligent buildings apply technologies to improve the building environment and functionality for occupants/tenants while controlling costs, improving security, comfort and accessibility.
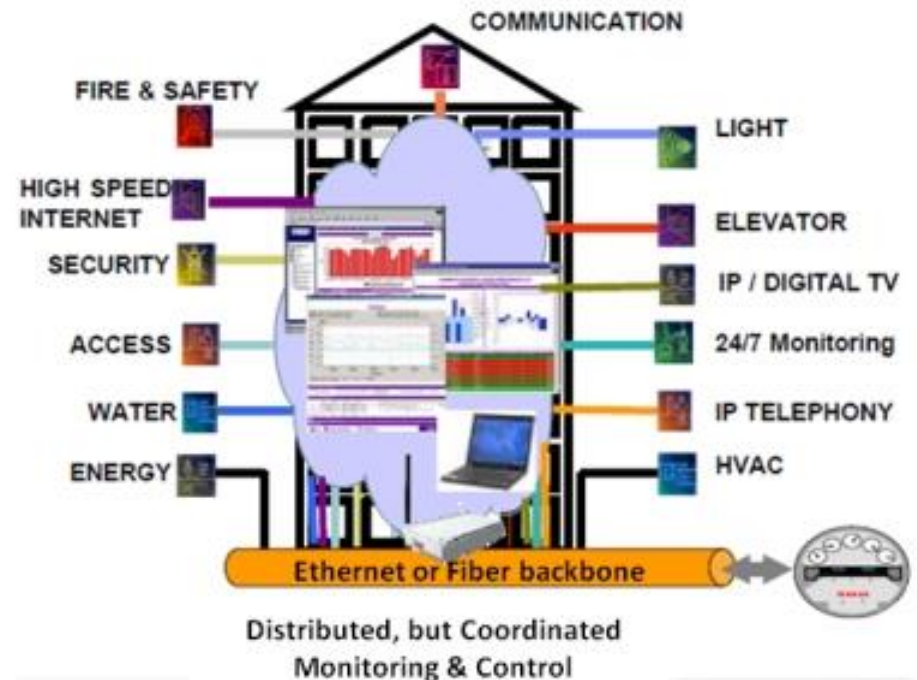
Efficient, Safe, Comfortable

History of Development of Intelligent Buildings (1)

- First coined in USA in early 1980s
- Its definition/model is evolving
  - Automated buildings (1981 - 1985)
  - Responsive buildings (1986 - 1991)
  - Effective buildings (1992 -)
  - Smart Buildings (2000~)
- Development of Intelligent Buildings
  - Closely linked with computers and information technology; high-tech related
  - But,
    Intelligent Building ≠ high-tech building

Single IP Network vs. Multiple Proprietary Networks

Fire/Life Safety
Interface Annunciation
View Functionality Only

Security
Intrusion Detection

Access/Video
Building, Doors, Garage
Elevator
Occupied Suites
Asset & Personnel Tracking

Elevators
Elevator Retrieval on Demand
Traffic Performance and Maintenance

Lighting
Schedules
Scenes
Shades
Light-Level Sensing
Occupancy Sensing

Energy Management
Utility Monitoring
  (Electric/Water/Gas/Oil)
Utility Purchasing
Back-Up Generation

24/7 Monitoring
Alarming & Notifications
Plant Management
Condition Monitoring
Parking Garage Utilization

HVAC
Air-Handling Units
VAV & CV Boxes
Exhaust Fans
Chilled Water Plant
Hot Water Plant
Energy Control
CO Monitoring
Air Quality

Communications
Voice/Video/Data

Multiple Control Environments

**Central Monitoring and Control**

History of Development of Intelligent Buildings (2)

- Intelligent Buildings in Europe Study (early 1990s)
  - "provides a responsive, effective and supportive intelligent environment within which the organization can achieve its business objectives"

- 3 main goals:
  1. Building management
  2. Space management
  3. Business management

COMMUNICATION

FIRE & SAFETY

HIGH SPEED INTERNET

SECURITY

ACCESS

WATER

ENERGY

LIGHT

ELEVATOR

IP / DIGITAL TV

24/7 Monitoring

IP TELEPHONY

HVAC

Ethernet or Fiber backbone

Distributed, but Coordinated Monitoring & Control

Defining Intelligent Building

- "An intelligent building is one that doesn't make the occupants look stupid."
  - Maximizes the *efficiency* of its occupants and allows *effective management* of resource with minimum life costs
  - More *responsive* to user needs and has the ability to *adapt* to new technology or changes in the organizational structures
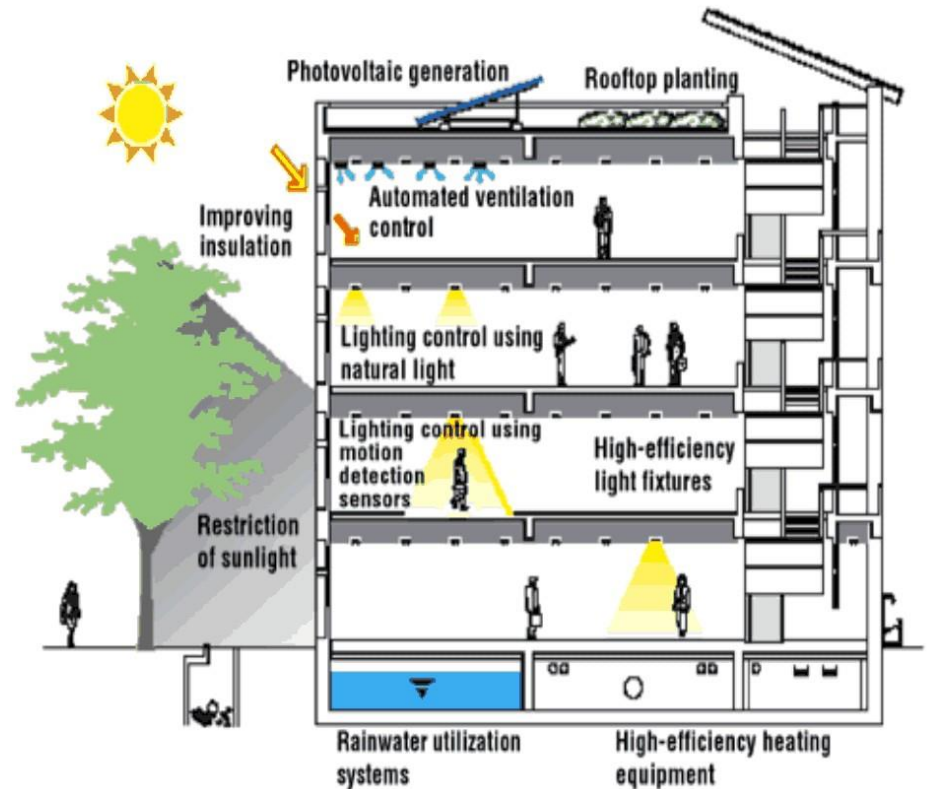
Definition of Intelligent Buildings

The Intelligent Building Institute has proposed:

"An intelligent building is one that provides a productive and cost-effective environment through optimization of its four basic elements - structure, systems, services and management - and the interrelationships between them. Intelligent buildings help business owners, property managers and occupants to realize their goals in the areas of cost, comfort, convenience, safety, long-term flexibility and marketability."

Objective of Intelligent Buildings

- 4 E's
  - Economy = minimizing cost
  - Efficiency = making best use of resources
  - Effectiveness = degree of achievement of outcome
  - Efficacy = degree of relevance of outcome

Goals of Intelligent Buildings

1. Building management:
   - Building automation and the physical environment

2. Space management:
   - Building's internal space & operating costs
   - Capabilities & flexibility of the building to accommodate changes, personal moves & connectivity

3. Business management
   - Management of the organization's core business

The Intelligent Building

IB Goals	IB Tasks		IB Attributes
Buiding management	Environmental control of building		**Building Automation systems (BA)**
	User control of building systems		
Space management	Management of change (capacity, adaptability, flexibility, manageability)	Design strategies and building shell attributes / Facility management strategies	**Computer Aided Facility Management systems (CAFM)**
	Minimization of operating costs		
Business management	Processing of information		**Communications**
	Storage of information		
	Presentation of information		Office automation
	Internal communications		Audiovisual systems
	External communications		Business systems

Stakeholder's Perspective

Site Maintenance

- Multiple systems to maintain
- Need productivity tools for day to day work
- Easy migration of legacy systems
- Limited training time !

- Reduce operating costs
- Maintain high quality service levels

- Department coordination
- Enterprise integration for business processes

Energy

- Develop energy saving strategies
  - Identify/ monitor energy usage
  - Reduce operating cost
- Deal with utilities, bills, rates
- Allocate costs or bill tenants

IT/ Security

- Network / Server uptime
- Data security & integrity
- Physical Security
  - Access control
  - Video surveillance
- Save energy consumption in datacenters

Consulting Eng.

- Open protocol systems
- Reliable solution
- Choice of vendors
- Easy to specify systems and verify operation

Owner/ CFO

- Planning & Budgeting
- Control operating costs
- Need proven ROI for spending
- Peace of mind!

Intelligent Building Characteristics
~ overview ~

- Designed around Users
- Improves Security
- Enhances Comfort
- Provides Energy Savings
- Enterprise-wide Energy Monitoring
- Everything Communicates
- Local Command and Control
- Remote Command and Control
- Accessible from Anywhere
- The right data to the right people
- Affordable
- Adds Value

Features of Intelligent Buildings

- Major intelligent building features
  - Automatic reactions (adjust internal conditions)
  - Effective communication and IT management
  - Responsiveness to changes
- Integrated pyramid
  - Single function/dedicated systems
  - Multifunctional systems
  - Integrated systems
  - Computer integrated building
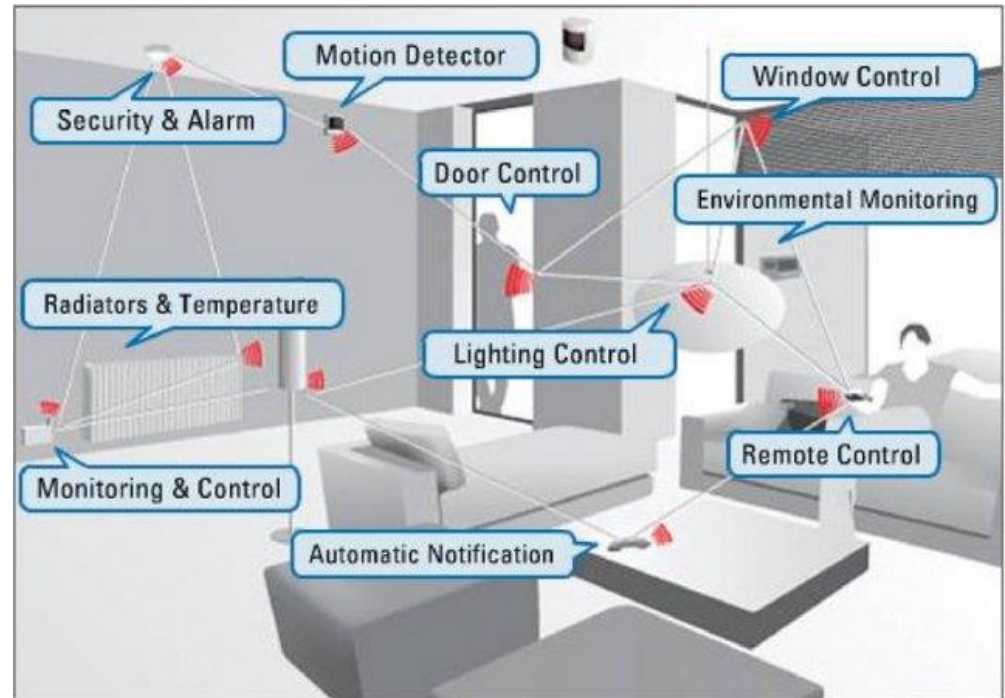
Assessment of Intelligent Buildings

1. environmental friendly - health and energy conservation (M1);
2. space utilization and flexibility (M2);
3. life cycle costing - operation and maintenance (M3);
4. human comfort (M4);
5. working efficiency (M5);
6. safety - fire, earthquake, disaster and structure etc. (M6);
7. culture (M7);
8. image of high technology (M8)
9. construction process and structure (M9); and
10. health and sanitation (M10)

Examples of How Technology Helped to Provide Energy Efficient and a Superior Environment

FEATURE

- Dimmable fluorescent lighting integrated with sun blind control
- Lighting control with motion sensors integrated with security & AI
- Natural and displacement ventilation

- Use of economizers for free cooling
- Individual temperature and lighting control
- Radiant heating and cooling
- After hours control of lights and HVAC integrated with security
- Monitoring of IAQ and contaminants

BENEFIT

- Optimal lighting level and quality can be determined by the occupants
- Reduces energy use and increases security
- More efficient and effective distribution of ventilation
- Energy efficiency
- Improved comfort is shown to improve productivity
- Improved comfort, reduced energy use
- Improved security while reducing energy use
- Improved comfort, safety, and productivity

Difference between Ordinary Buildings and Intelligent Buildings (1)

- Intelligent building adjusts the inside functional aspects such as lighting, ventilation, air conditioning, etc. automatically with the changes in environmental conditions controlled by computer

- Ordinary building there will be different room conditions depending on the changes in the environmental conditions.

Difference between Ordinary Buildings and Intelligent Buildings (2)

- While planning an Intelligent Building, a Building service engineer, an Architect and a Hardware Engineer are required.

- But in case of ordinary building, a Building service engineer and an Architect is enough.

Difference between Ordinary Buildings and Intelligent Buildings (3)

- In an Intelligent Building, the security system, communication system, etc. are coordinated and automatically controlled by computer work station.

- The cost of construction of Intelligent Building is very high as compared to an ordinary building.

- The development cost of an Intelligent Building is 8 - 10% higher than that of an ordinary building. But this can be justified by the resulting energy saving, which is only $25 \pm 35\%$ of energy required by normal building.

Communications Technologies

- Intelligent building use Intelligent Communications Technologies.

- Technologies that centralize and integrate:
  - Monitoring
  - Control
  - Operation and Management of building(s) services

  Telephone system, Wired internet/WiFi, Lora, 5G for Industrial 4.0 (AGV, smart HVAC, smart grid,VR/AR/MR); Building BMS: BacNet, Modbus; AI-based communication system

How Buildings Become Intelligent

- The high technology concept of intelligent building systems was introduced in United States in early 1980's.
- An Intelligent Building provides a productive and cost-effective environment through the integration of Structure, Systems, Services, and Management.
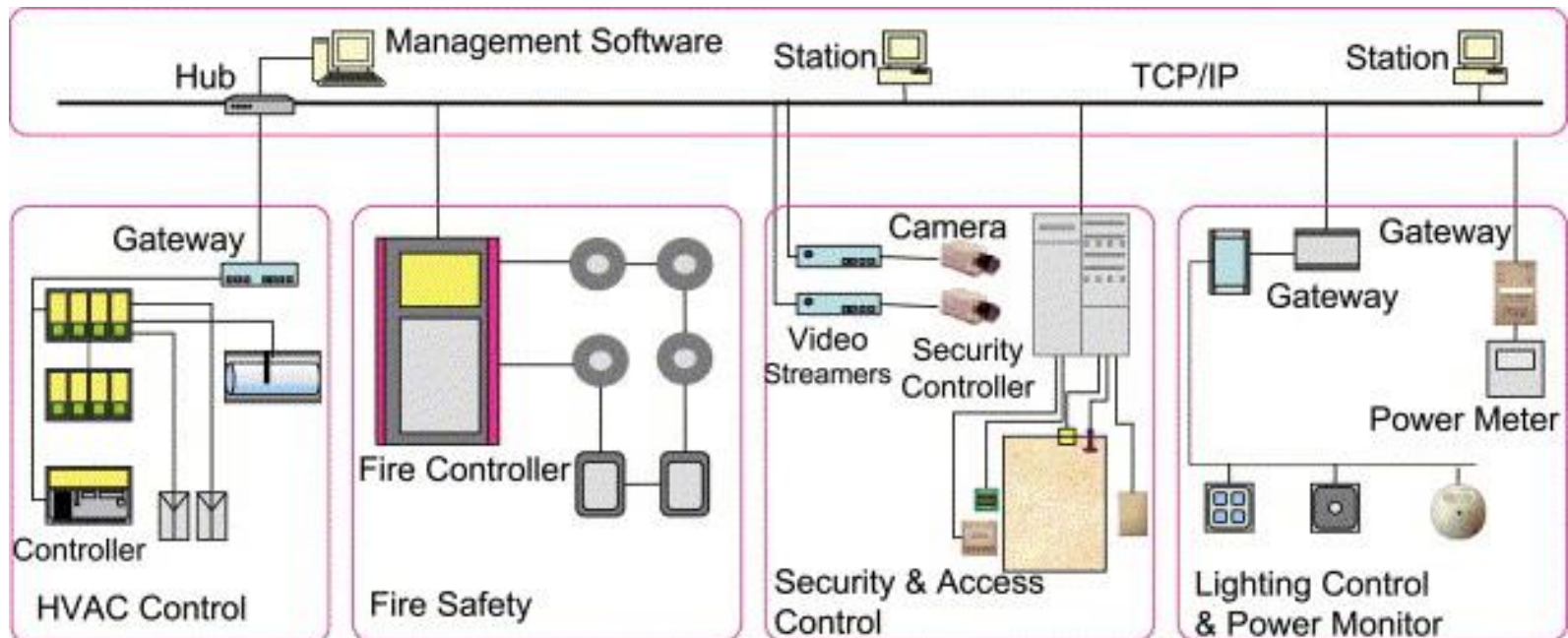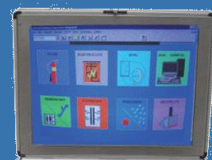
intelligent

Library systems

Unified messaging
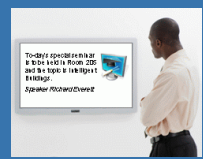
Cause and effect

Building Mgmt Systems

Learning technology

Smart cards

Infrastructure

Wireless

iB

Trend analysis

mLearning

AV

IP telephony

Digital signage

Room management

Cashless catering

Thin client Blade PCs

Buildings

Major Aspects of Intelligent Building

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

LIFTS
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
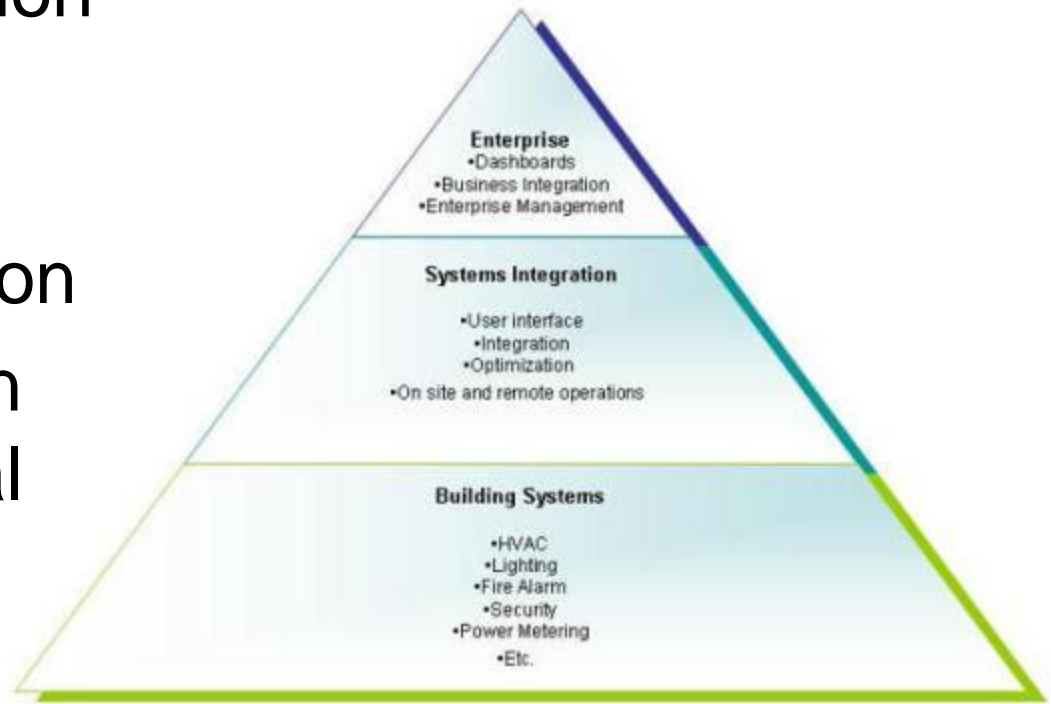
E G W

Three Dimensions of Building Intelligence

1. Building Automation System

2. Advanced Telecommunication

3. Office Automation System and Local Area Network

Enterprise
- Dashboards
- Business Integration
- Enterprise Management

Systems Integration
- User interface
- Integration
- Optimization
- On site and remote operations

Building Systems
- HVAC
- Lighting
- Fire Alarm
- Security
- Power Metering
- Etc.

Intelligent Building Model

Building Automation System

To enable the building to respond to external factors and conditions (like climatic variations, fire, etc.), simultaneous sensing, control and monitoring of the internal environment and the storage of the data generated.
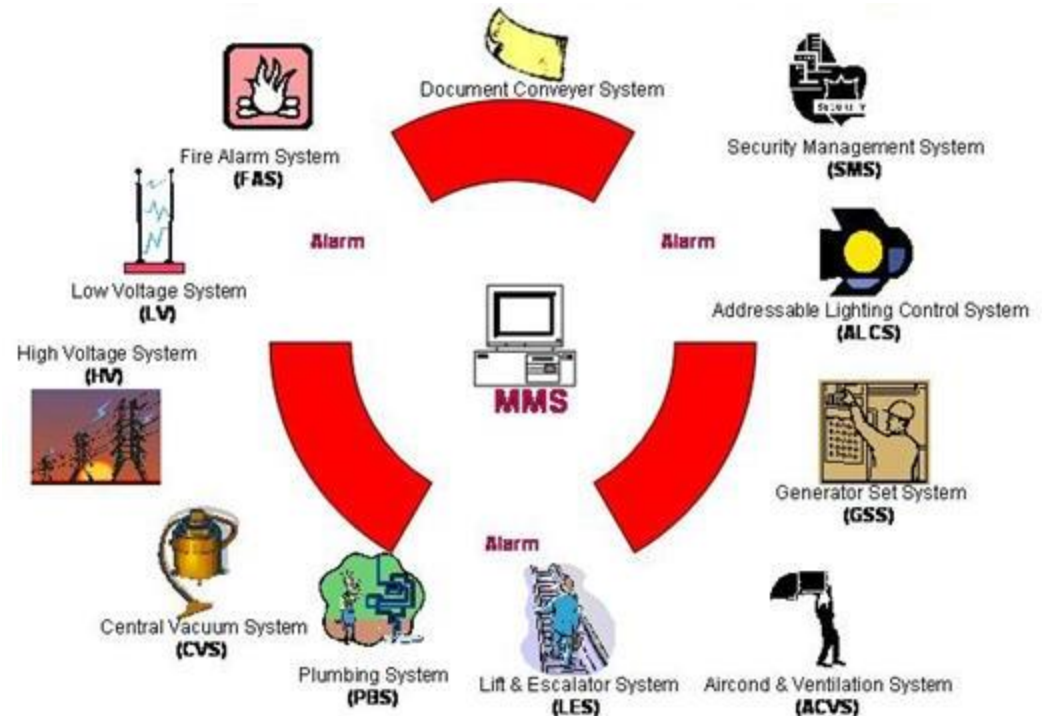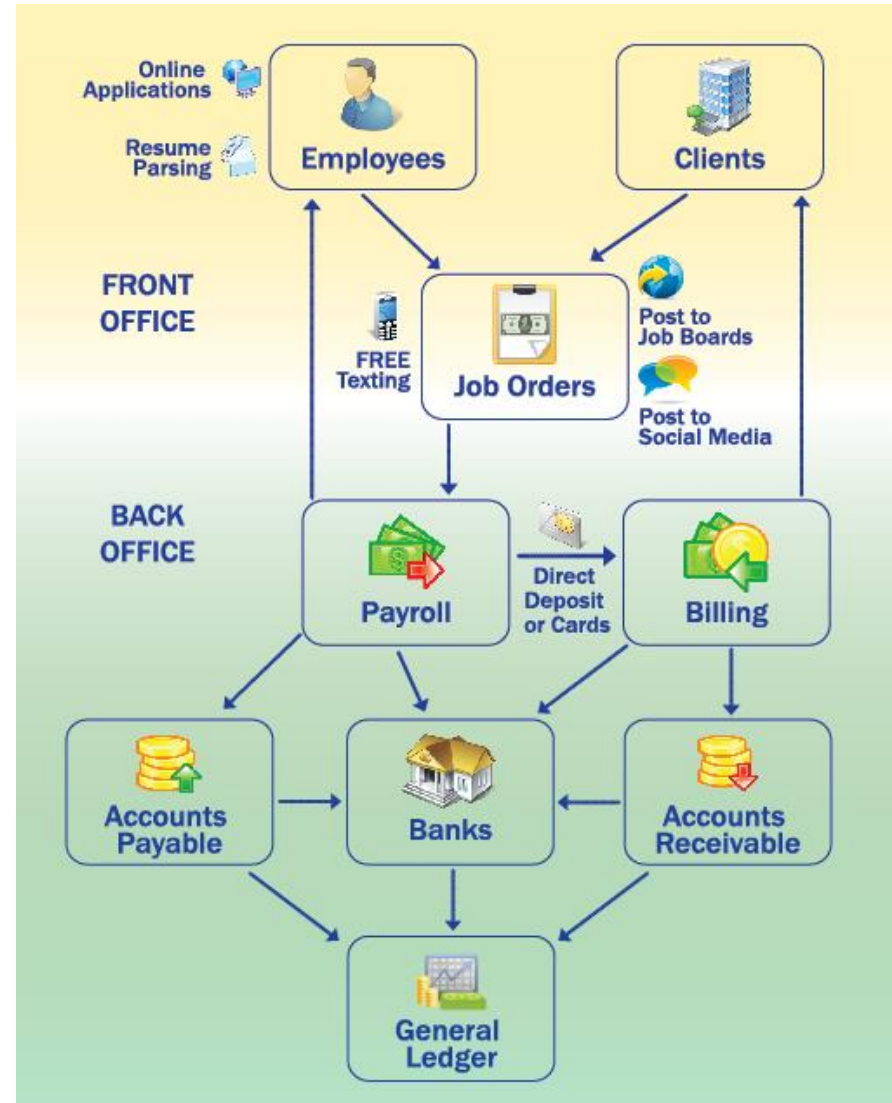
Advanced Telecommunication

To enable rapid communication with outside world, via the central computer system using optical fiber installations, microwave and conventional satellite links.

Office Automation System and Local Area Network

To provide management information and decision support aid with link to the central computer system.

Building Systems

- Indoor comfort
  - temperature
  - humidity
  - indoor air quality
  - CO_2 concentration
  - pathogens control
- Water supply
  - sanitation / purification
- Lighting and automation
  - sensors
- Information and security
- Thermal energy
- Electricity

Power Logistics

- On-site power generator
- Small-scale renewable energy
  - solar heat
  - solar PV
  - wind power
- Fuel cells and hydrogen
  - on-site power plant
  - co-generation
  - hydrogen storage
- Batteries
  - emergency power
  - power conditioning

Components of an Intelligent Building (1)

- Integration of various building systems via BMS (building management system)
  - Energy management system
  - Lighting management system
  - Security systems & fire safety
  - Telecommunications & office automation
  - Local area networks (LANs)
  - Cabling management
  - Intelligent maintenance mgt. system (IMMS)
  - Computer aided facility management (CAFM)

Components of an Intelligent Building (2)

Major categories (a):

- **Energy efficiency**
  - energy management and control
- **Lifesafety systems**
  - fire alarm
  - security
- **Telecommunications** systems
  - PABX telephone,
  - videotext
  - cablevision
  - e-mail

Major categories (b):

- **Workplace automation**
  - data processing
  - word processing
  - CAD
  - information services

Components of an Intelligent Building (3)

- Common needs of intelligent building tenants:
  - Built-in Internet wiring
  - LAN/WAN connectivity
  - Conduits for cabling
  - High-tech HVAC
  - Wiring for high-speed networks

- Critical performance qualities
  - Functional or spatial quality
  - Thermal quality
  - Air quality
  - Aural quality
  - Visual quality
  - Building integrity

Intelligent Buildings @ Work (1)

- Office space and commercial buildings
  - Speculative offices (USA or European)
  - Organizational/functional requirements
  - Impact of Information Technology and business strategy
- Objectives
  - Responsive (to user needs / to climate)
  - Efficient (building design & systems)
  - Effective (operation & management)
  - Better integration (with Information Technology and within systems)

Intelligent Buildings @ Work (2)

- Current and future development
  - New ways of working
    - More interaction
    - More collaboration (physically or electronically)
    - More individual autonomy
  - New patterns of space use
    - More group spaces
    - More shared spaces
    - More space for concentration
    - More intermittent space use

- Major systems
  - Building automation system (BAS)
  - Office automation system (OAS)
  - Communication automation system (CAS)
- Criteria
  - Business value/benfits
  - Efficiency
  - Effectiveness

Intelligent Buildings @ Home (1)

- Present technology
  - Phones and intercoms
  - Home automation
  - Audio distribution (e.g. hi-fi speaker)
  - Video distribution (e.g. TV)
  - Video surveillance (e.g. security)
  - Structured wiring
  - Home theater, game station

Intelligent Buildings @ Home (2)

- Future home
  - Home networking
  - Internet appliances
  - Webcam, web phones
  - e-books, video walls
  - Home office
  - Virtual clinic/hospital
  - ……

Surf the web without wires!

Intelligent Building Perspective ....

any device (Smart Machine) becomes a Point for Service Delivery to the enterprises

Digital Video surveillance

Access control

Intrusion detection

Alarms management

Asset Tracking

**Energy / Inventory ….
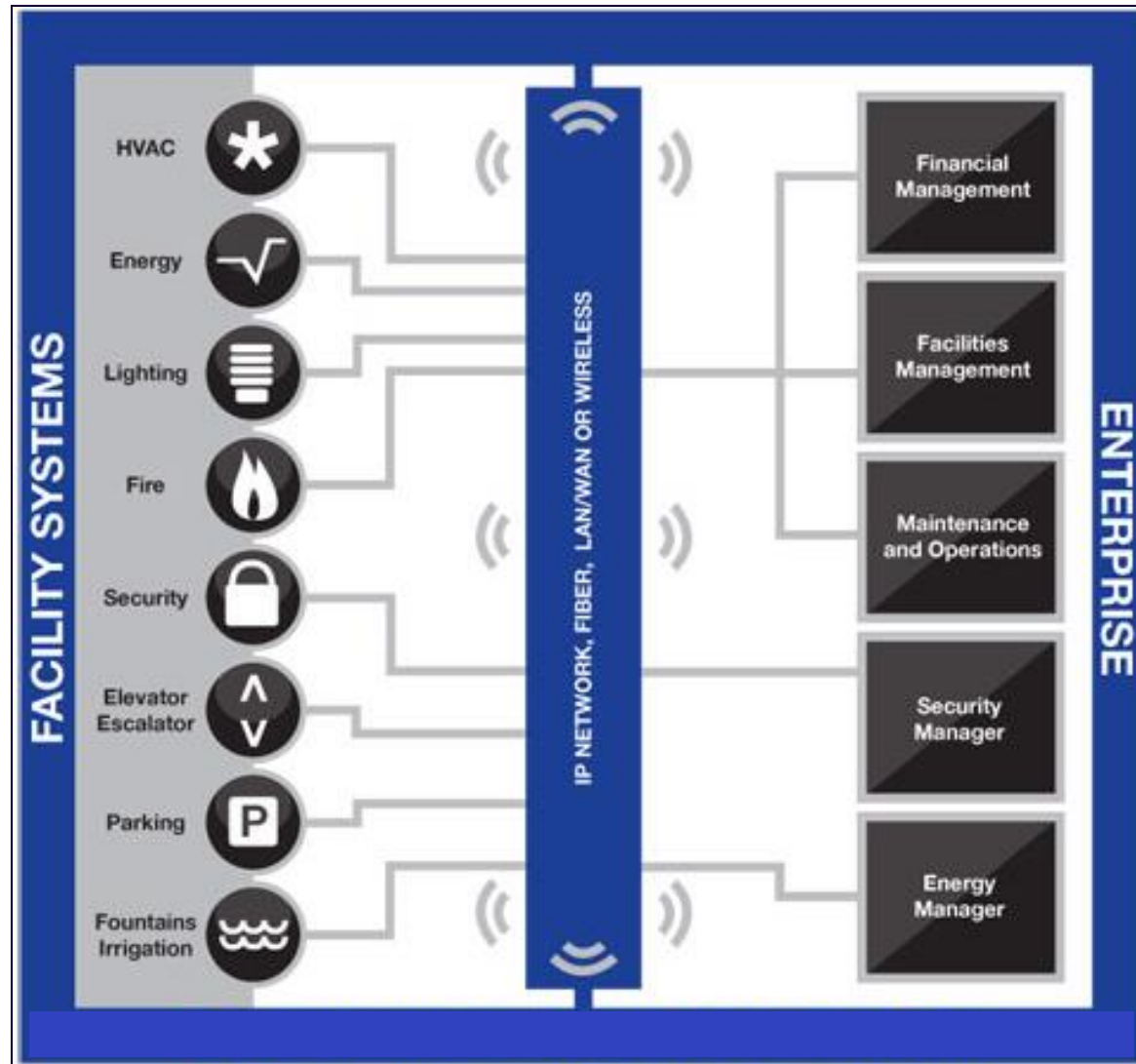Management**

Fire alarm

Intelligent Building Systems (1)

- Modern buildings utilize sophisticated, computer controlled engineering systems to maintain a comfortable, energy saving, green and safe environment for their occupants, such as

    Δ Building Energy Control System
    Δ Building Safety Control System
    Δ Indoor Air Quality Control System and,
    Δ Building Security and Defense System

- Similar engineering systems are used to create the right environment (temperature & humidity levels) for food and medicine processing, preservation and transportation. The Building Services Engineers/Researchers are employed by the industry for the design, cost estimation, installation and management of these systems and for the distribution, testing and servicing of their components.

Intelligent Building Systems (2)

- Candidate technologies applicable to the following subsystems will be considered for an intelligent building:

  a) Vertical transport (elevators and escalators)
  b) HVAC
  c) Life safety
  d) Lighting
  e) Security and access control
  f) Energy management and power distribution
  g) Tenant telecommunications (telephone, data networks)
  h) Communications within the public spaces (public address, elevators)
  i) Building structure monitoring (leaks, corrosion, earthquake, etc.)

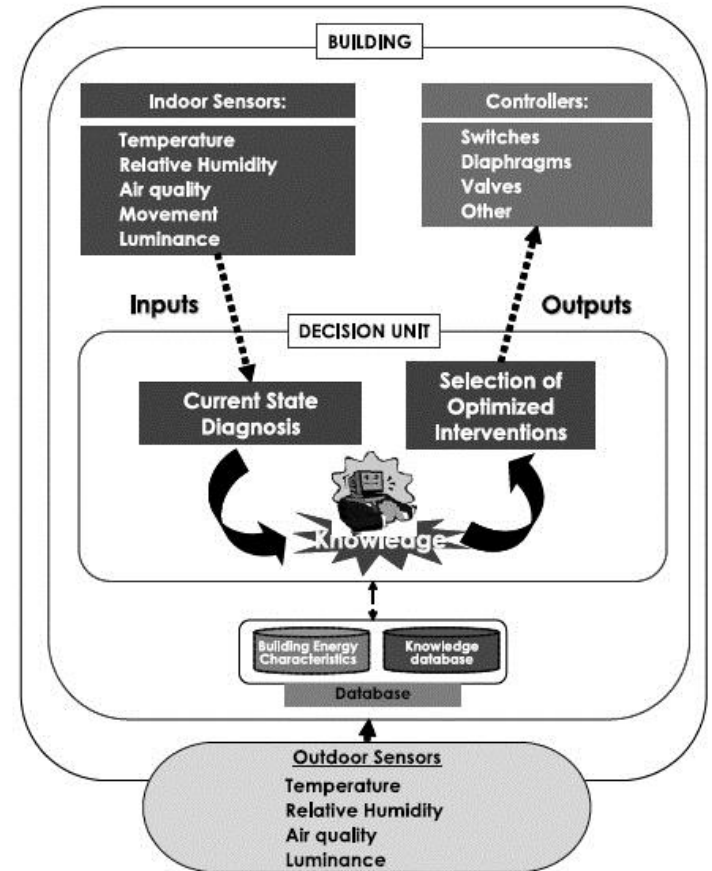# Intelligent Building Systems (3)

Intelligent Building Management System

Intelligent Building Energy Management System

- As energy is required for almost every intelligent building systems for the whole life cycle of use of the buildings, it is important that energy is efficiently managed to:

  a. the guarantee of the desirable levels of living quality in all building's rooms

  b. the necessity for energy savings

- Some of the intelligent building systems require high quality of energy supply that on-site power generation is preferred (Tier 4 Data Center since 2005)

Economy Consideration

- Creating an intelligent building does require an investment in advanced technology, processes, and solutions.
- An upfront investment is required to realize a significant return later on. It is unrealistic to expect to make a project intelligent unless there is early buy in on investment.
- One of the challenges is to educate owners on the benefits of an intelligent building design.
- This makes the education of both owners and architects about the benefits of intelligent solutions critical for success.
- Good management of maintenance and energy could save the subsequent costs of the building

Building Smart, Building Green…

Intelligent building technologies can improve buildings' energy efficiency and indoor environmental quality.

Commonalities

Green Building   **Intelligent Building**

Integrated design

Eco-friendly materials

Individual comfort control

Ecological site
planning

Indoor environmental quality

Advanced security
and communications
systems

Productive workplace

Water efficiency

Flexibility

Energy efficiency

Advanced structural
system

Automatic climate response

Transportation
efficiency

Advanced controls