Building Energy Management & Control Systems

Introduction and Basic Cocepts

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- Overview
- Control Fundamentals
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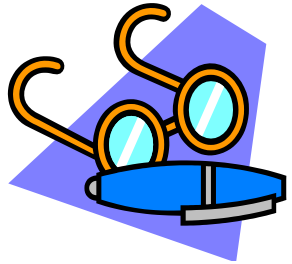
Study Guide

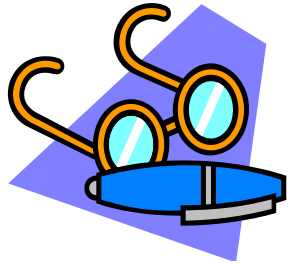
- Educational Objectives
  - To introduce basic concepts of computer-based integrated monitoring, control and energy management for building services installations
  - To study the principles of design and operation of building energy management and control systems (EMCS) and their applications to buildings
  - To understand methods of performance analysis of building services systems using building EMCS

Overview



- Terminology
  - Building automation system (BAS)
  - Building management system (BMS)
  - Building energy management system (BEMS)
  - Energy management system (EMS)
  - Central control monitoring system (CCMS)
  - Direct digital control (DDC)
  - Intelligent building (IB)

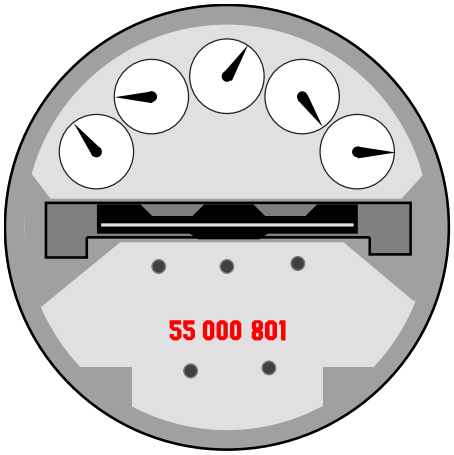
Overview



- Building services systems being controlled
  - HVAC (heating, ventilation & air-conditioning)
  - Fire services
  - Plumbing & drainage
  - Electrical installations
  - Lighting
  - Lifts & escalators
  - Security & communication
  - Special systems e.g. medical gas

Building Energy Management System

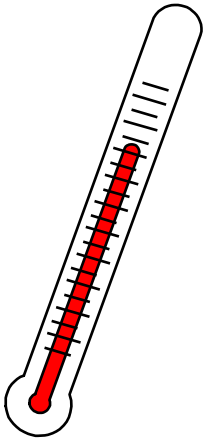
Lower energy cost



Lower operations cost

Increase flexibility

Ensure quality building environment



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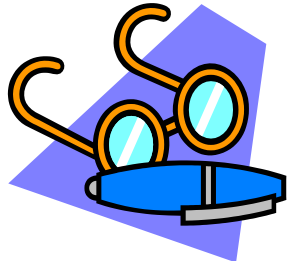
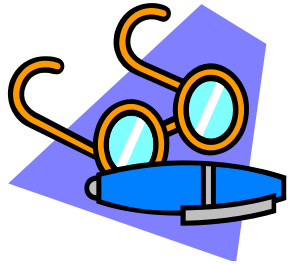
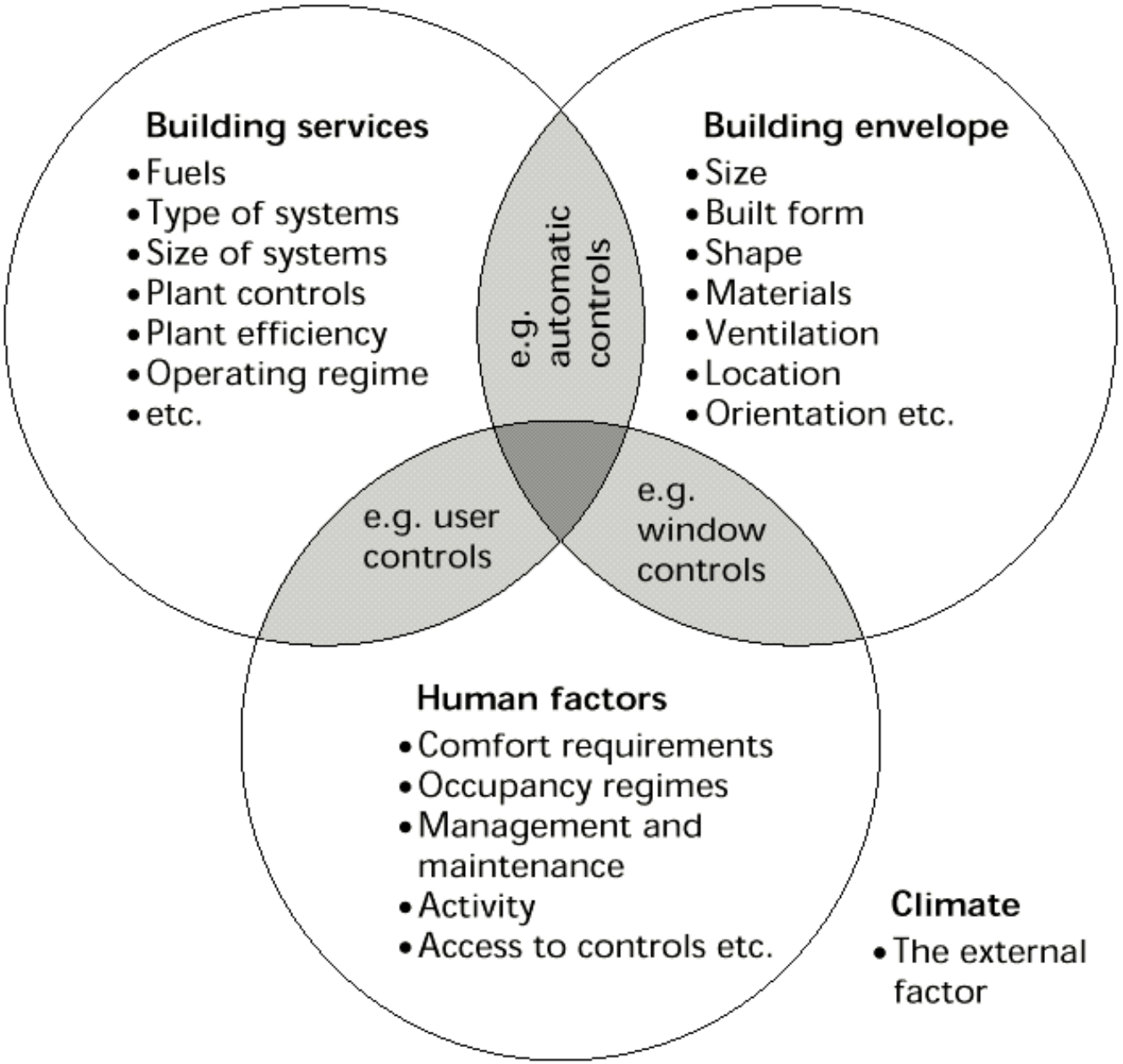


- Why use BEMS?
  - Growing complexity of building systems
  - Demand for more efficient building operation
  - Need to save energy & operating costs
  - Need to increase flexibility & reliability
  - Improve indoor environment & productivity
- Connect BEMS to major building equipment to
  - Control air conditioning & lighting to save energy
  - Monitor all equipment to improve efficiency of operations personnel & minimise equipment down time

Overview

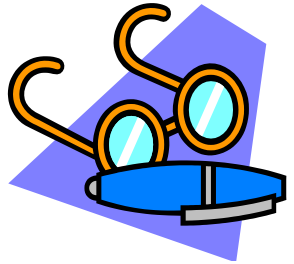


- Factors affecting energy use in buildings
  - Thermal efficiency of building envelope
    - Thermal insulation, air tightness, solar gains
  - Requirements of indoor environment
    - Temperature schedule, ventilation needs, humidity control, indoor air quality, lighting, lifts, etc.
  - Processes within the building
    - IT or office equipment, industrial processes



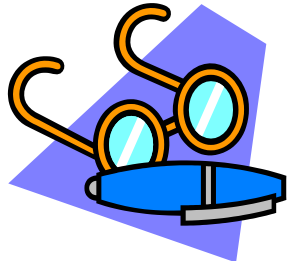
Key factors influencing energy consumption

Overview

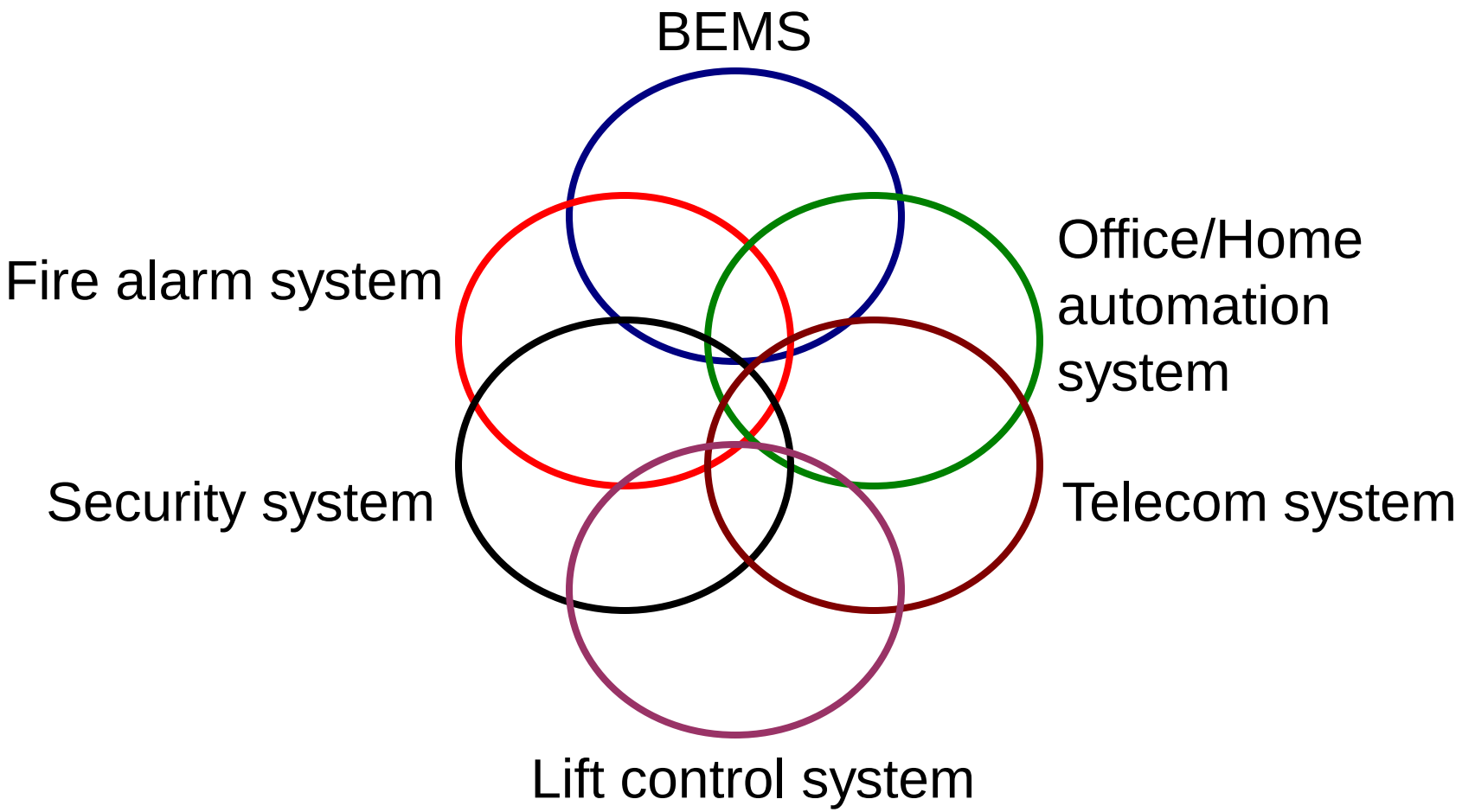


- Early development history
  - 1st generation (1950's)
    - Remote monitoring panels with sensors & switches (hard wire)
  - 2nd generation (1960's)
    - Electronic low voltage circuits
  - 3rd generation (1960's-1973)
    - Multiplexed systems with minicomputer stations
  - 4rd generation (1983)
    - Microcomputer-based systems
  - 5th generation (1987)
    - Direct digital control (DDC) with microprocessor & software

Overview

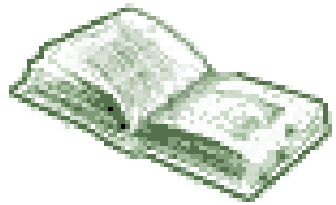


- Recent trends
  - Conventional system (front end based)
    - Central computer + “dumb” field panels
  - Distributed intelligence BEMS
    - Central computer + field panels (limited standalone)
  - Fully distributed BEMS
    - Multifunction microprocessor close to the equipment (complete standalone)



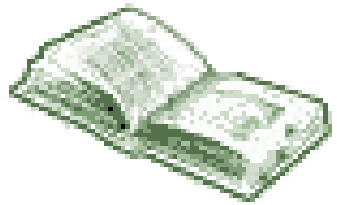
Potential overlap of microprocessor-based systems

Control Fundamentals

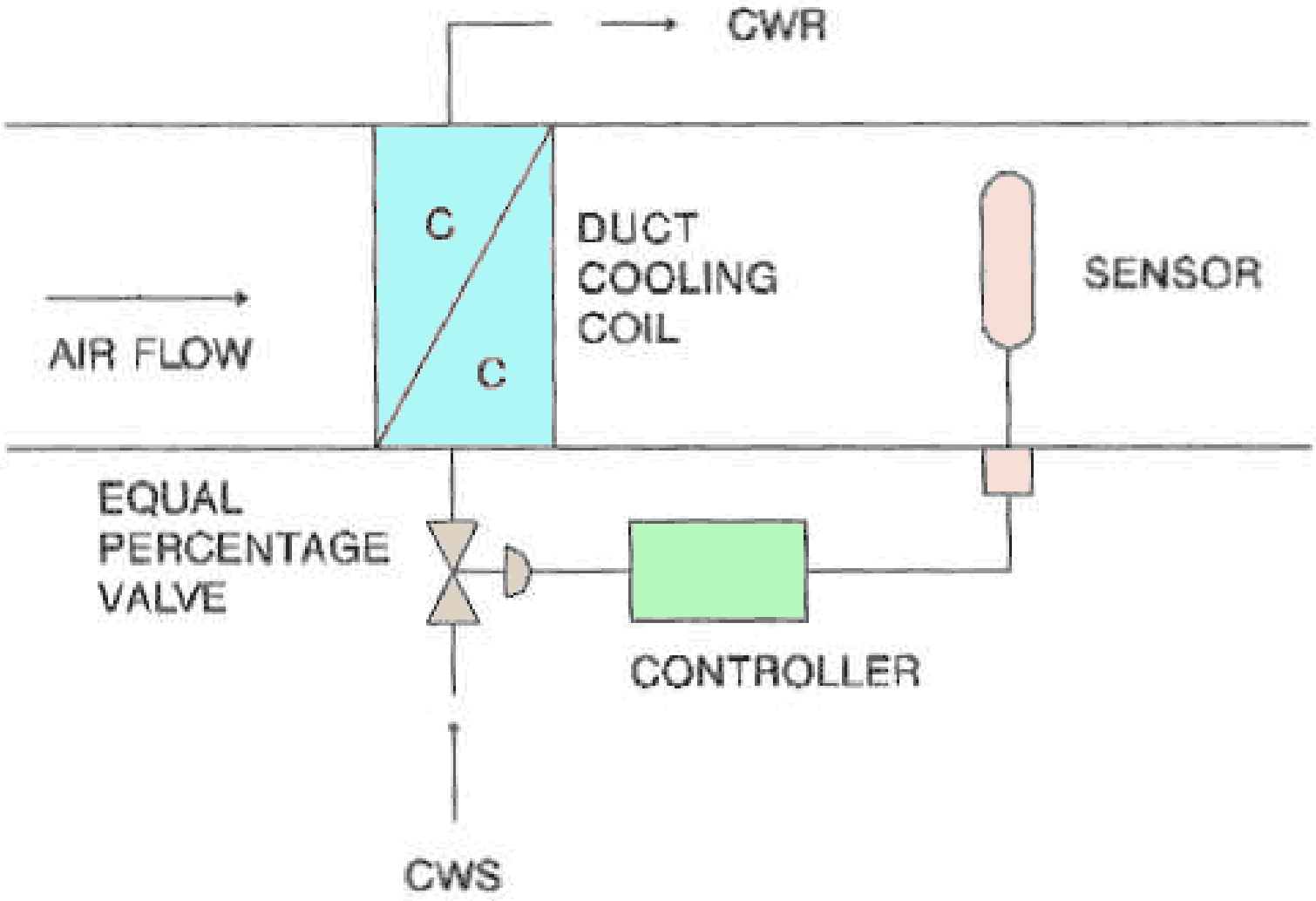


- Pneumatic controls
  - Traditional form of control used in buildings
  - Pneumatic controllers, sensors & actuators
  - Electronic devices may be integrated
- Direct digital control (DDC)
  - Entered the HVAC industry in late 1980's
  - Use a programmable microprocessor as controller
    - 'Direct' = microprocessor is directly in the control loop
    - 'Digital' = control is accomplished by the digital electronics

Control Fundamentals

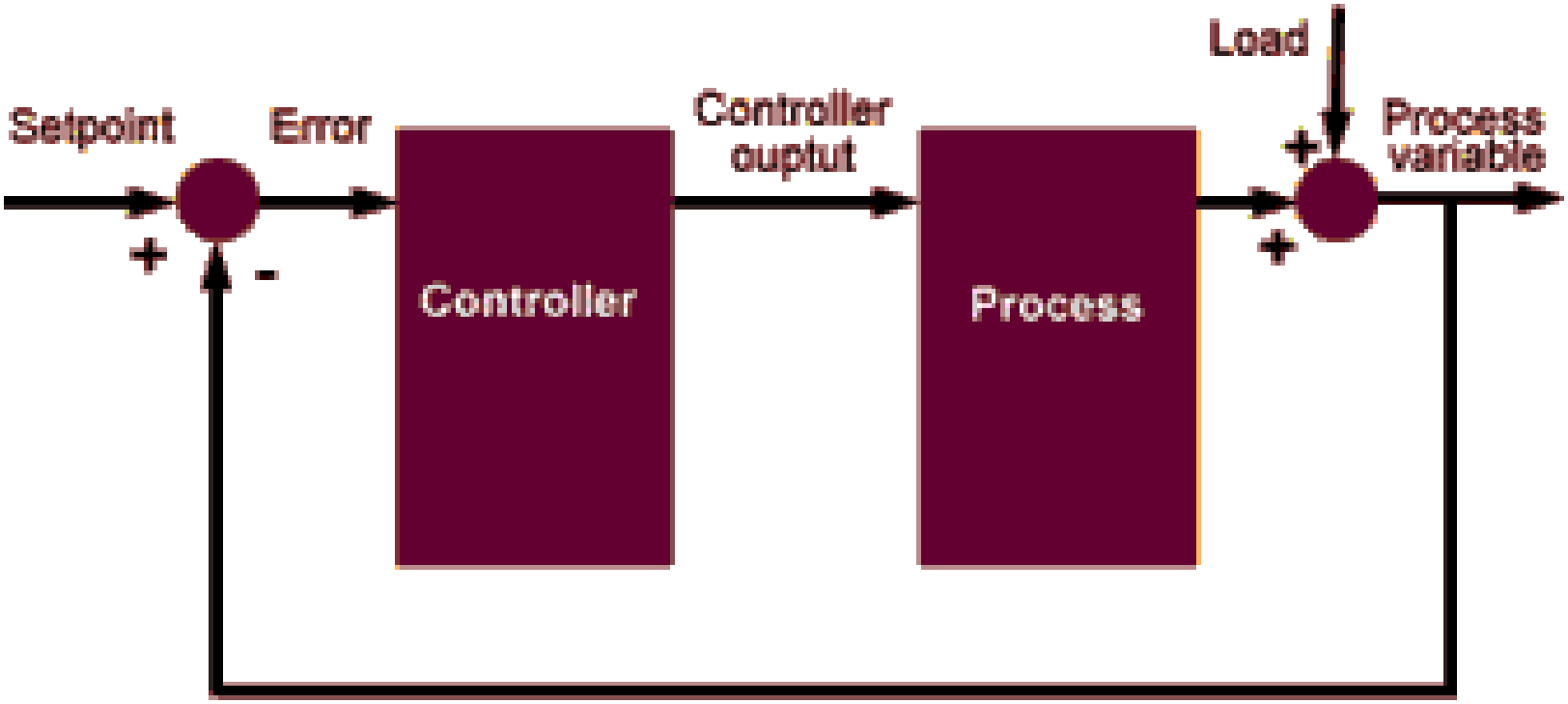


- Basic elements
  - Sensor
    - Measure some variables, e.g. temperature
  - Controller
    - Process & compute an output signal
  - Controlled device
    - Act to change the output of the load
- Typical situation for BEMS
  - Close loop systems (w/ feedback loop)



Discharge air control system

A Typical Feedback Control System



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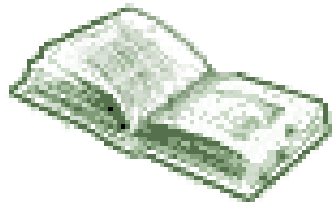
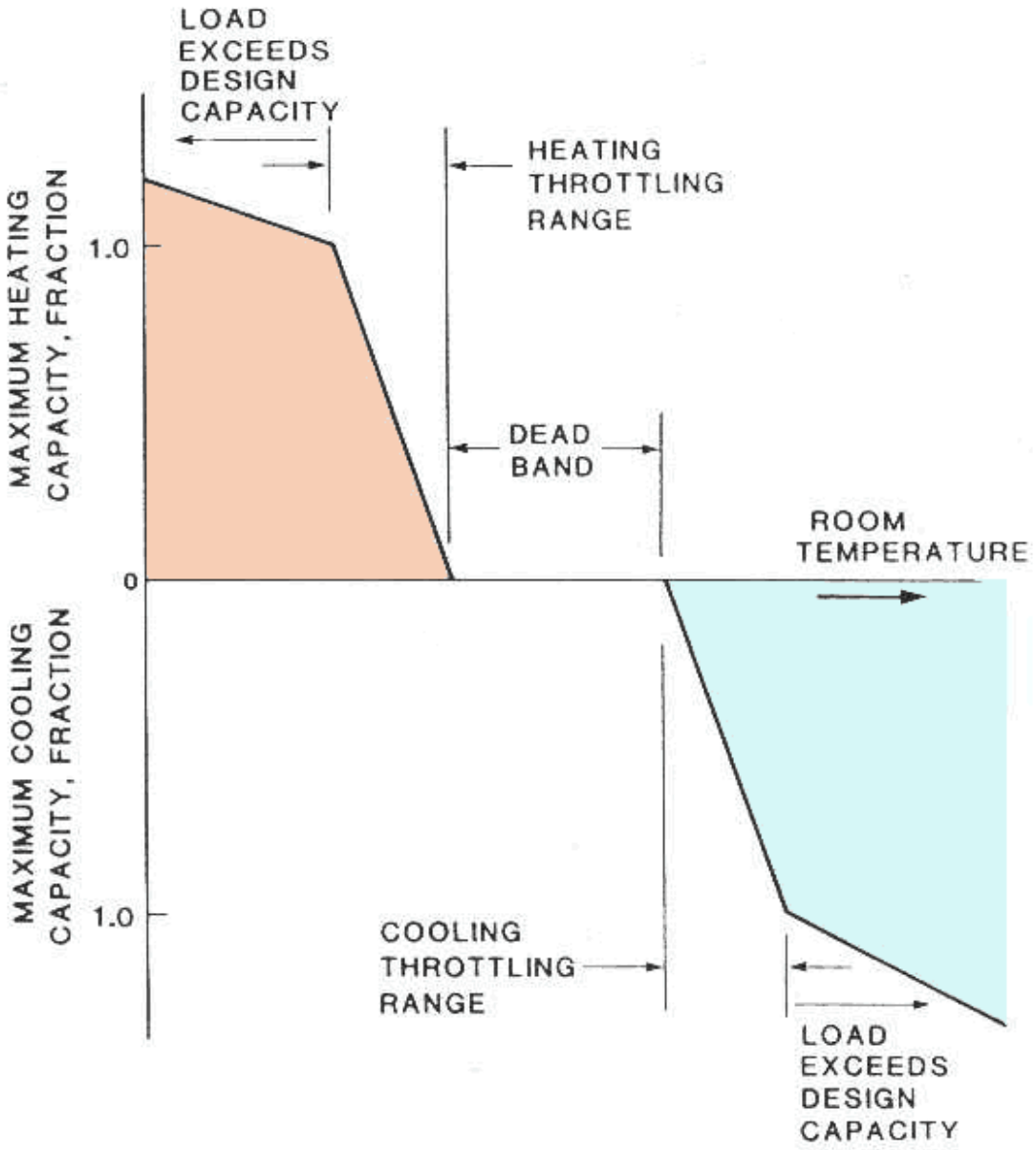
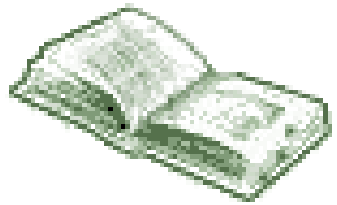


- Control modes
  - Two position (on/off) control
  - Proportional control
  - Integral control
  - Proportional + integral (PI) control
  - Proportional + integral + derivative (PID) control
- Technical terms
  - Set points, dead band, throttling range, offset, proportional band, integral time



Thermostat model of proportional control with deadband and dual throttling range

Control Fundamentals

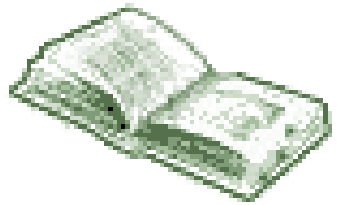


- Choice of control mode
  - Degree of accuracy required; amount of offset
  - Type of load changes expected
    - Including amplitude, frequency & duration
  - System characteristics
    - Such as no. & duration of time lags, speed of response
  - Expected start-up situation
- In general, use the SIMPLEST mode

Recommended control modes for HVAC system

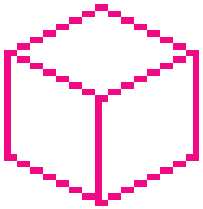
Application	**Control mode**
Space temperature	P
Mixed air temperature	PI
Coil discharge temperature	PI
Chiller discharge temperature	PI
Air flow	PI (use wide proportional band & short integral time), PID
Fan static pressure	PI (some may require PID)
Humidity	P, possibly PI for tight control
Dewpoint	P, possibly PI for tight control

Control Fundamentals



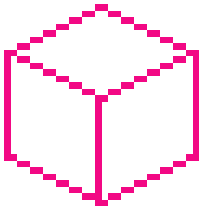
- Other advanced control techniques
  - Adaptive control
    - Controllers ‘learn’ the plant/system operating conditions by observing the response to disturbances
  - Fuzzy logic
    - Based on a set of rules of the IF-THEN type, expressed in near natural language
  - Neural network
    - Reproduce the way the human brain leans by experience; non-linear processing

System Concepts



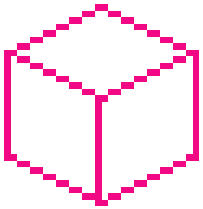
- Typical procedure for a BEMS project
  - Initial concept
  - Information retrieval
  - Candidate buildings & system selection
  - Field survey
  - Design
  - Prepare contract documents
  - Contract
  - Installation & training
  - Acceptance
  - Operation & maintenance

System Concepts

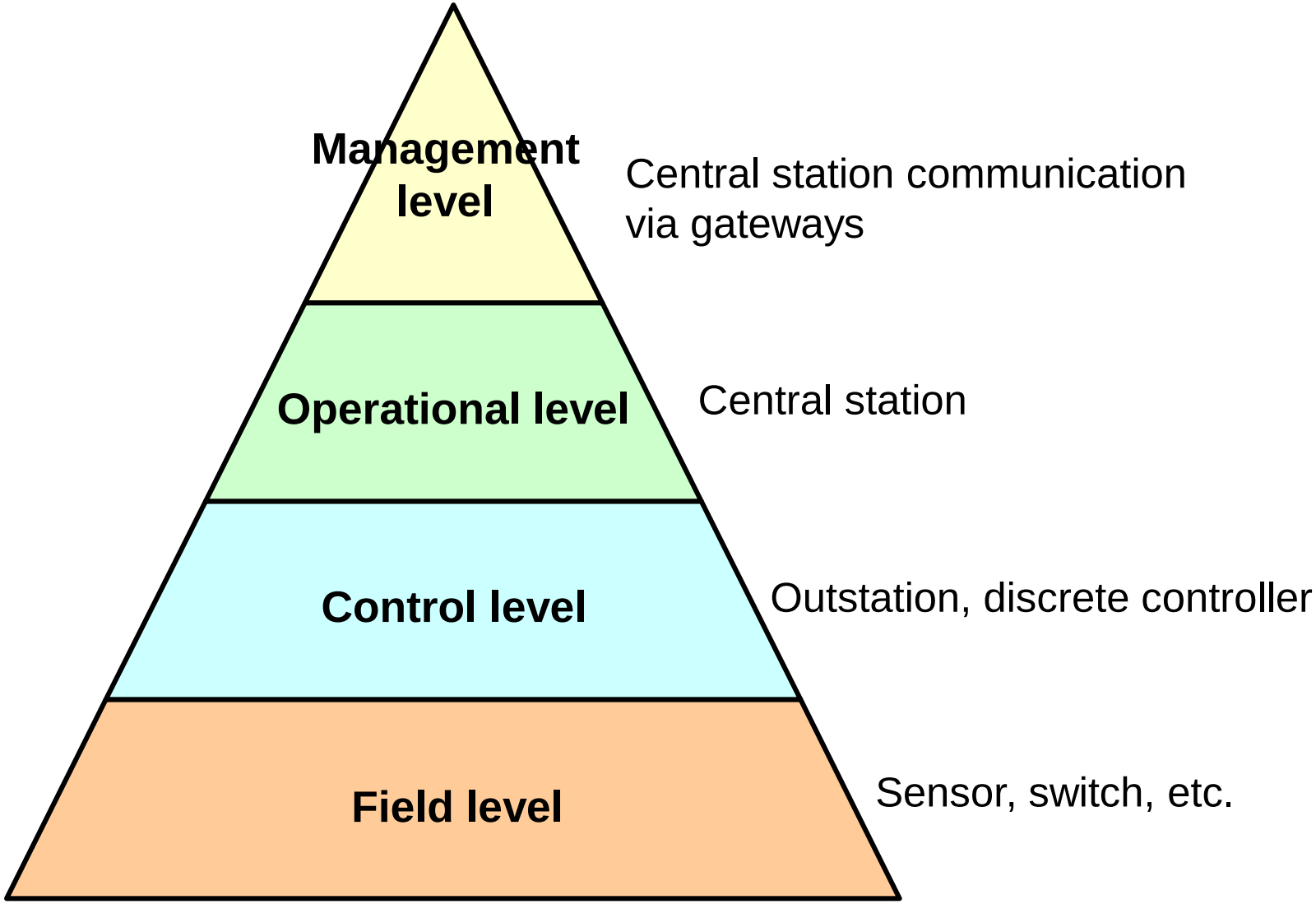


- Common BEMS software functions
  - Programmed start/stop: occupancy schedules
  - Optimised start/stop: based on indoor/outdoor temperatures
  - Thermostat temperature setback/setup
  - Economizer control: use “free cooling”
  - Reset of air, chilled water or hot water temps.
  - Chiller or boiler optimisation
  - Demand control: reduce peak electrical loads

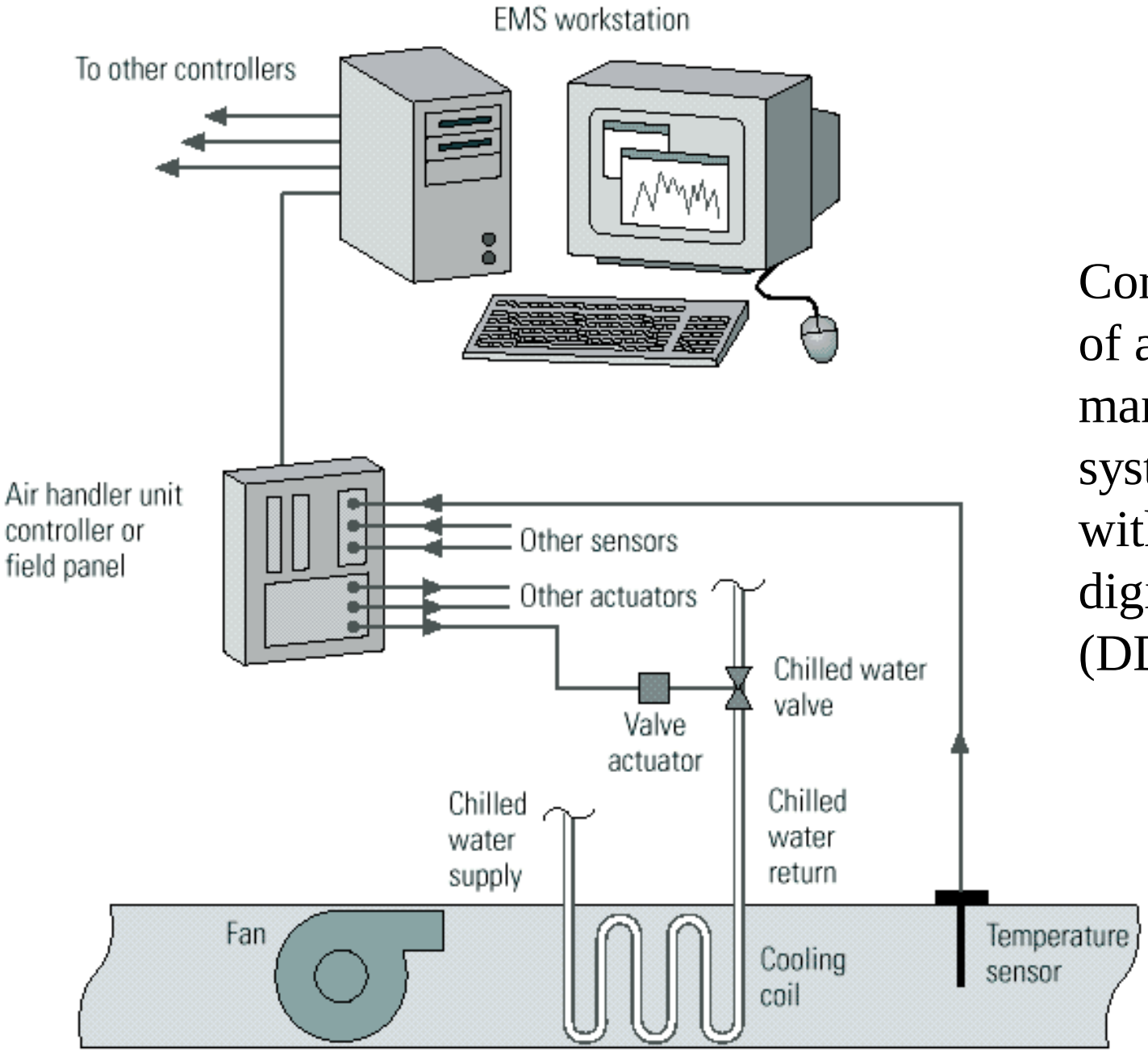
System Concepts



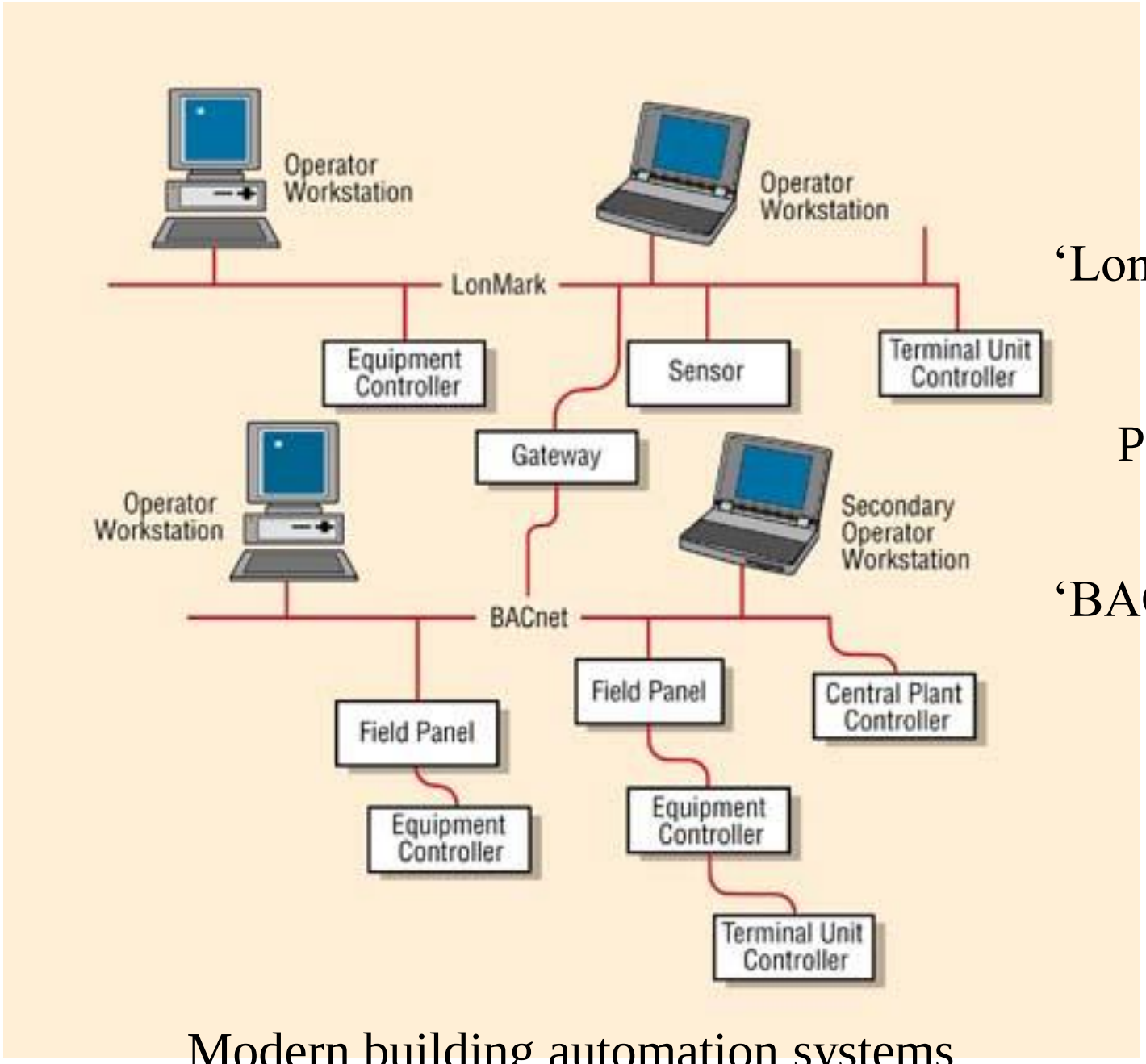
- Common BEMS software functions (cont'd)
  - Duty cycling: turn off equipment for some time to reduce energy use
  - Monitoring/alarm: logging conditions, on-off/high-low alarms, run time, energy use, etc.
  - Fire notification: parallel with fire alarm system
  - Security: alarm, door switches, etc.
  - Card access: card readers, exit doors, door contacts, etc.



Levels of control in building energy management system



Components of a energy management system (EMS) with direct digital control (DDC)



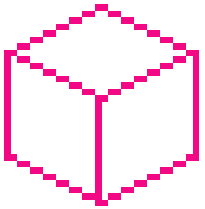
‘LonMark’

Protocols

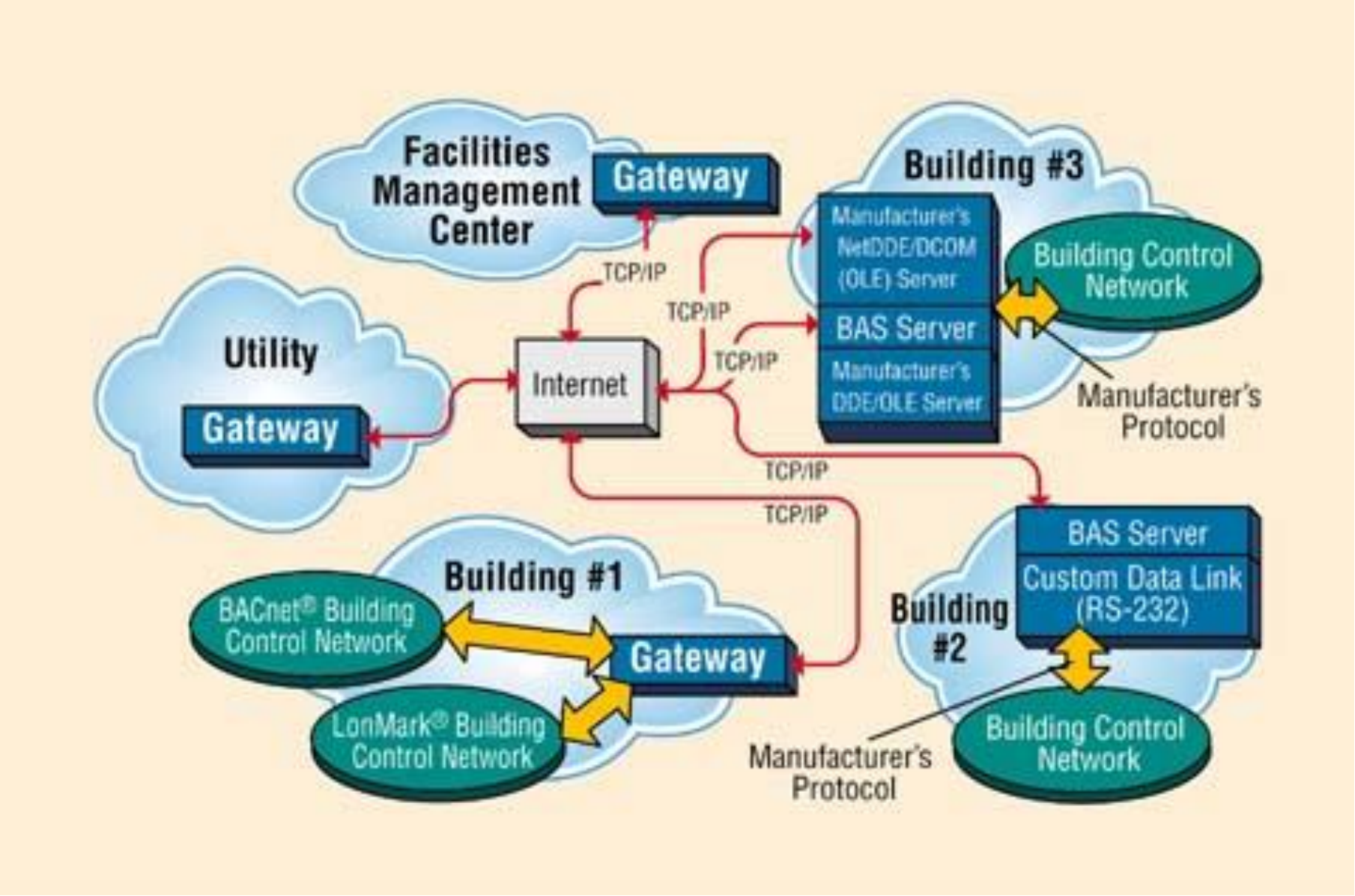
‘BACnet’

Modern building automation systems

System Concepts



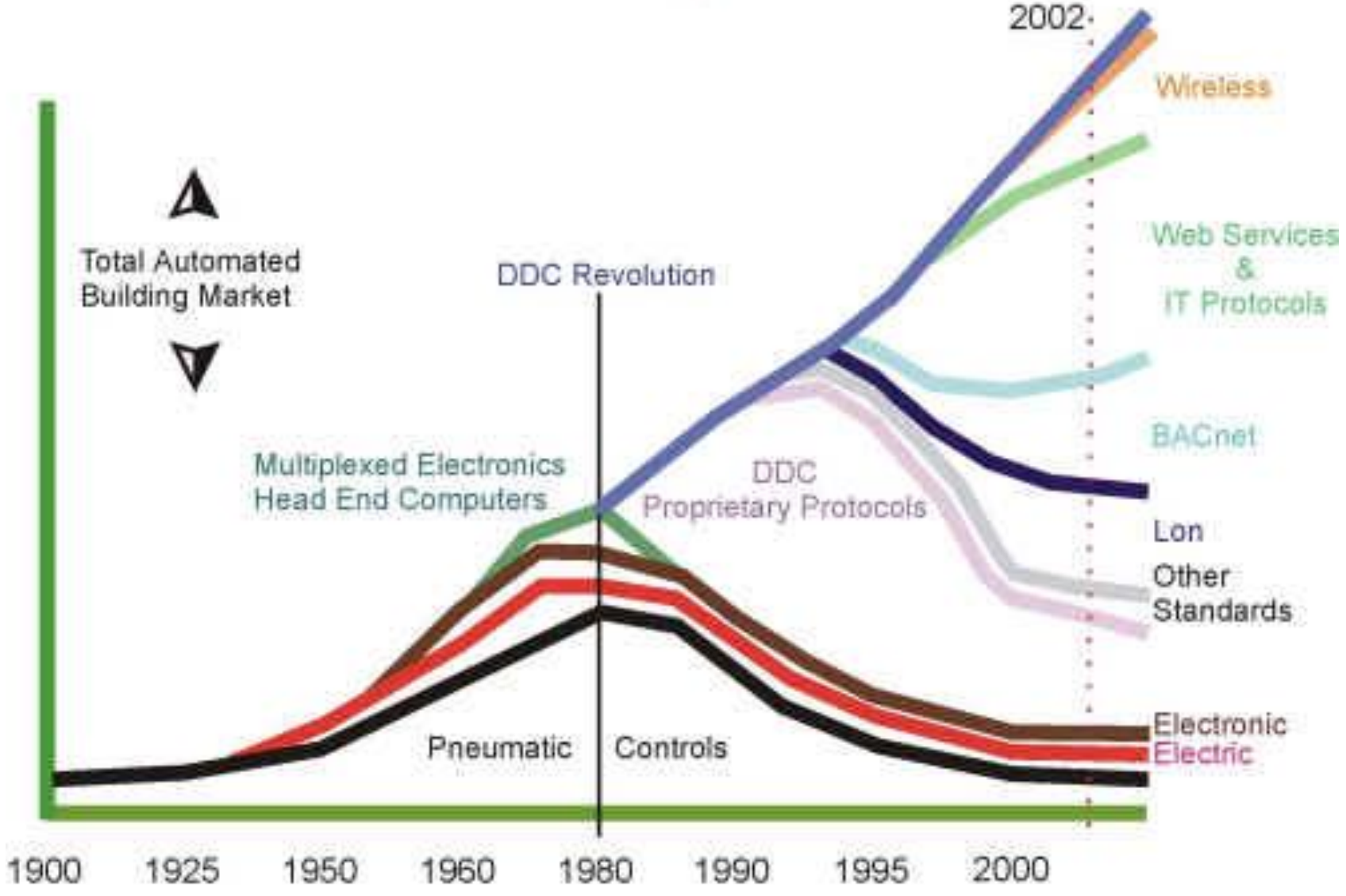
- Future development potentials
  - World Wide Web (Web-based controls)
  - Communication standards (BACnet & LonMark)
  - Wireless revolution
  - Integration of communication & automation
- Emerging issues
  - ‘Green’ building environment
  - Evolution of DDC to facility wide control
  - Occupant connectivity & control



Integration controls network from different buildings

Wireless revolution

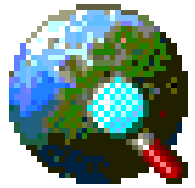
Automated Buildings Evolution



AutomatedBuildings.com

evolution.cdr

Further Reading



- Building automation: an overview of central control and monitoring systems
  - http://www.nrc.ca/irc/cbd/cbd214e.html
- AutomatedBuildings
  - http://www.automatedbuildings.com/
- 11 Revolutionary Automation Trends
  - http://www.automatedbuildings.com/news/may01/articles/trends/trends.htm