Data and Information Management in the Built Environment

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Definition of Built Environment

Various Sources (Google, ScienceDirect):

- Human-made surroundings that provide for human activity, ranging in scale from buildings to cities.
- Includes supporting infrastructure: water supply networks; energy networks; transportation systems, communication systems.

Human Needs:

- Basic: Access to clean air and clean water.
- Health: Access to good medical services.
- Economic: Affordable low maintenance housing.
- Security: Protections against crime, environmental attack.

Definition of Built Environment

- Transportation: Good roads; parking; fast access to work.
- Educational: Access to good schools.
- Green Spaces: Access to parks, bike paths, etc.
- Retail: Access to shopping; reliable supply chains.
- Lifestyle: Access to social and recreational spaces.

Urban Planning and Engineering Concerns:

- Understand short- and long-term planning needs.
- Efficiency in design – aesthetically pleasing design.
- Efficiency in operations – better use of limited resources.
- Improved response to unexpected events.

Framing the Opportunity

We seek:

- Data-driven approaches to measurement of performance in the building environment and identification of trends and patterns in behavior.
- Solutions that account for unique physical, economic, social and cultural characteristics of individual cities.

Sources of Complication:

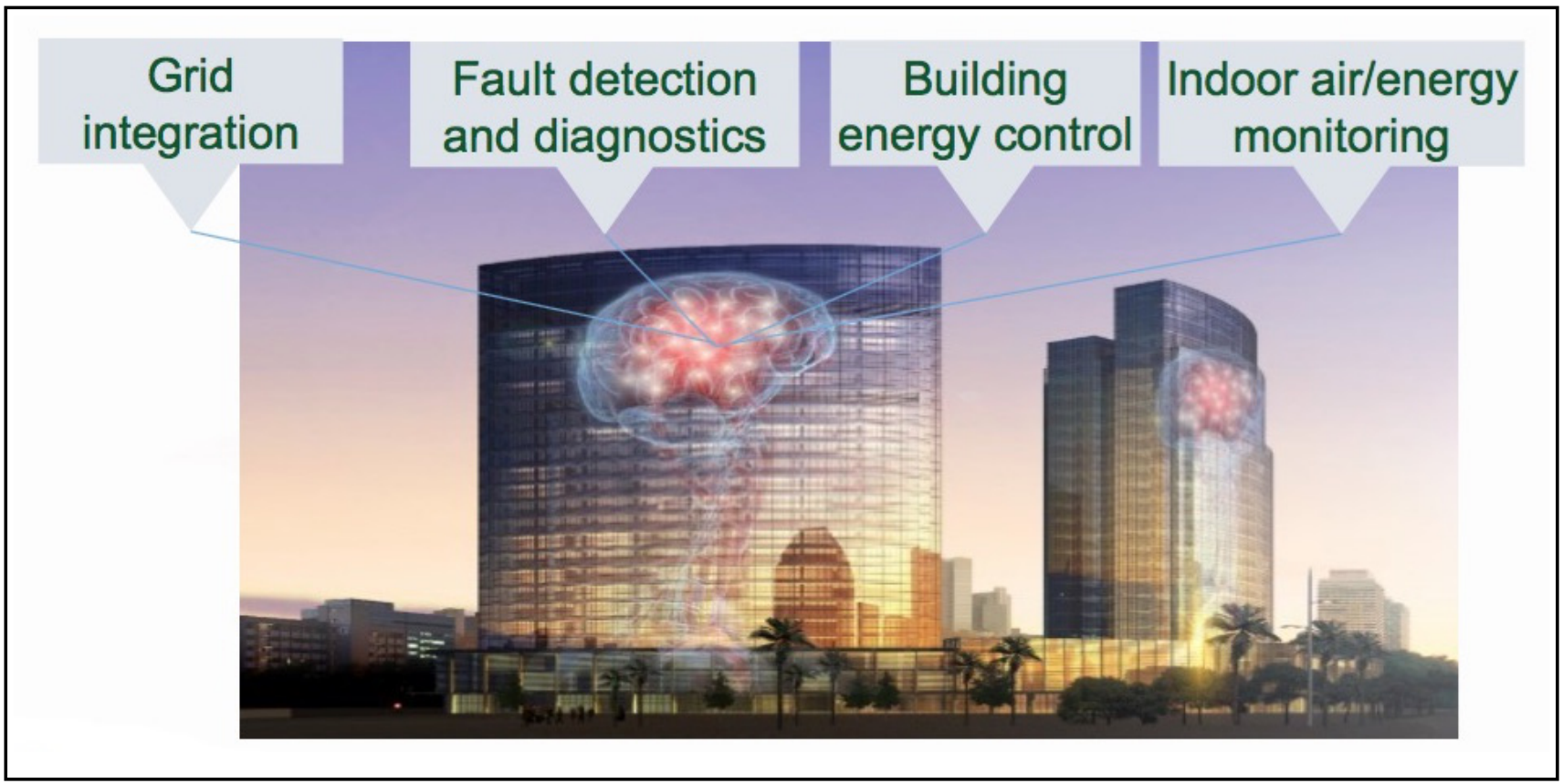
- Multiple domains; multiple types of data and information.
- Network structures that are spatial and interwoven.
- Behaviors that are distributed and concurrent.
- Many interdependencies among coupled urban subsystems.

Urban Applications

How do buildings and cities work?

Modern Buildings (Vision for Future)

Buildings that Think! (Work at NIST/UMD 2017)



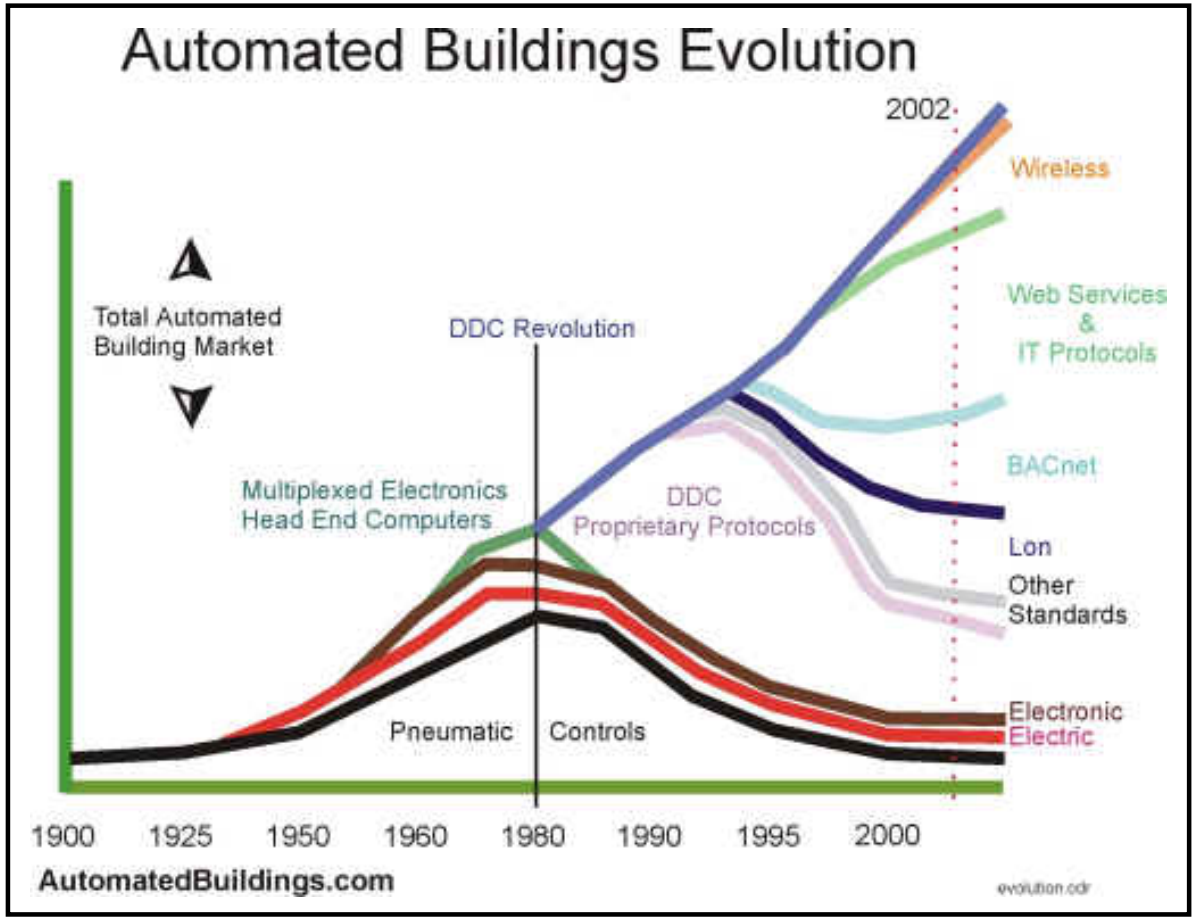
Modern Buildings (Key Features)

Modern buildings are:

- Advanced, self-contained and tightly controlled environments design to provide services (e.g., transportation, lighting, etc).
- Large size (e.g., 30,000 occupants, thousands of points of sensing and control for air quality and fire protection).
- Many stakeholders; highly multi-disciplinary.
- Building have networks for: arrangement of spaces; fixed circulatory systems (power, hvac); dynamic circulatory systems (flows of energy).
- Many sources of heterogeneous data.
- Necessity of performance-based design and real-time management.
- System functionality controlled by software!

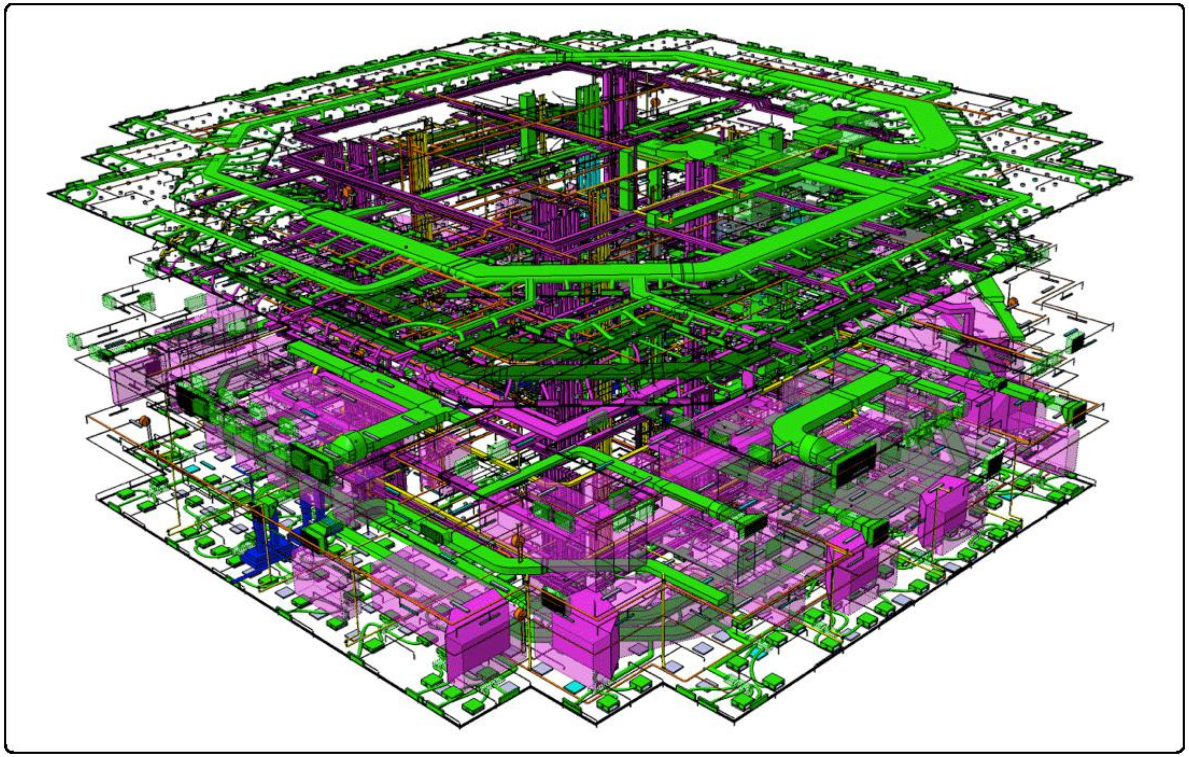
Modern Buildings (Key Features)

Large-scale building systems are packed with automation:



Modern Buildings (Key Features)

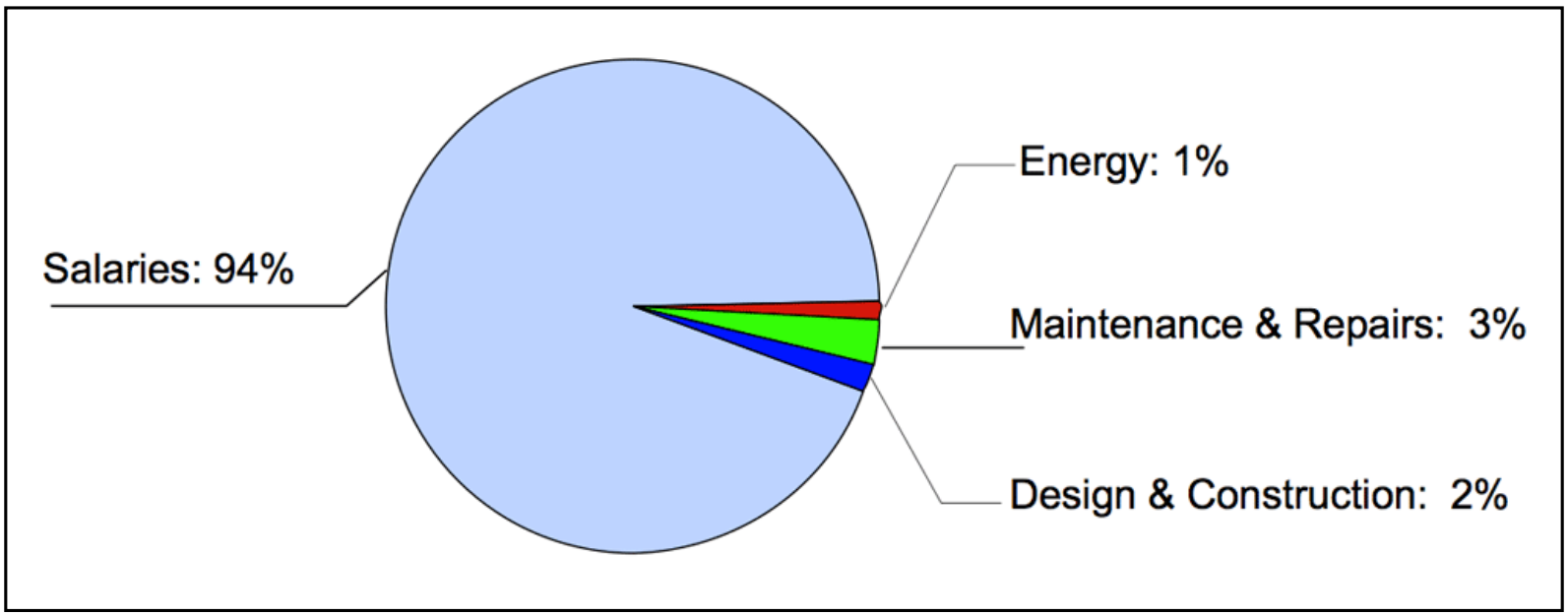
Large-scale building systems are intertwined networks of networks:



Understanding the relationships among the networks and their combined behaviors can be very challenging.

Modern Buildings (Economics)

Lifecycle costs in office buildings over a 30-Year period:



Energy systems have a huge impact on building occupant comfort and indoor air quality which, in turn, affects salary performance.

Source: United Technologies Research Center, 2009.

Modern Buildings (Integrated Energy Systems)

Trend toward Integrated Energy Systems:

- Commercial and residential buildings consume 1/3 of the world's energy.
- And by 2025, buildings will consume more energy than the transportation and industrial sectors combined.
- Standard models of building operation rely on centrally produced power as a source of high-grade energy.
- Advances in technology allow for consideration of alternatives, such as local production of power.

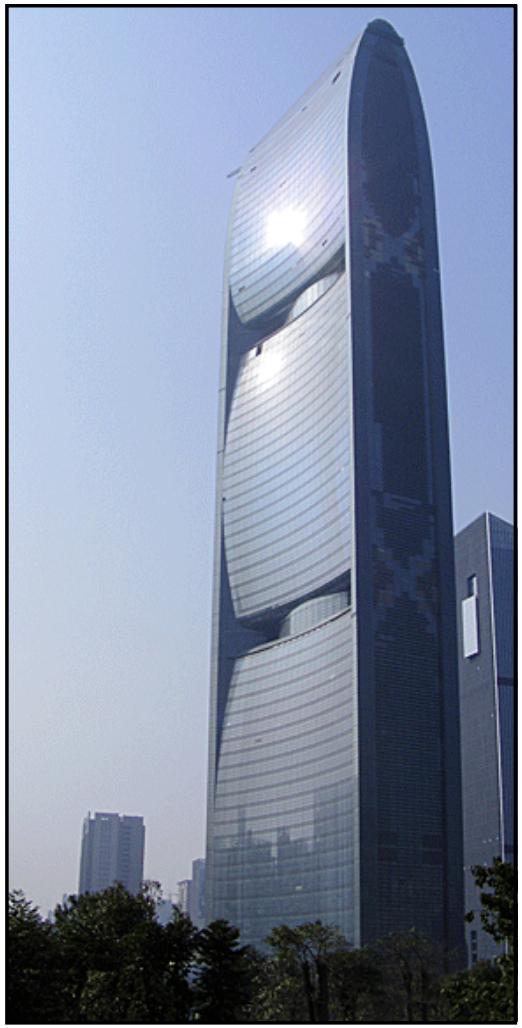
Examples:

- Solar power; small-scale combined heat and power systems.
- Electricity production through use of ducted wind turbines.

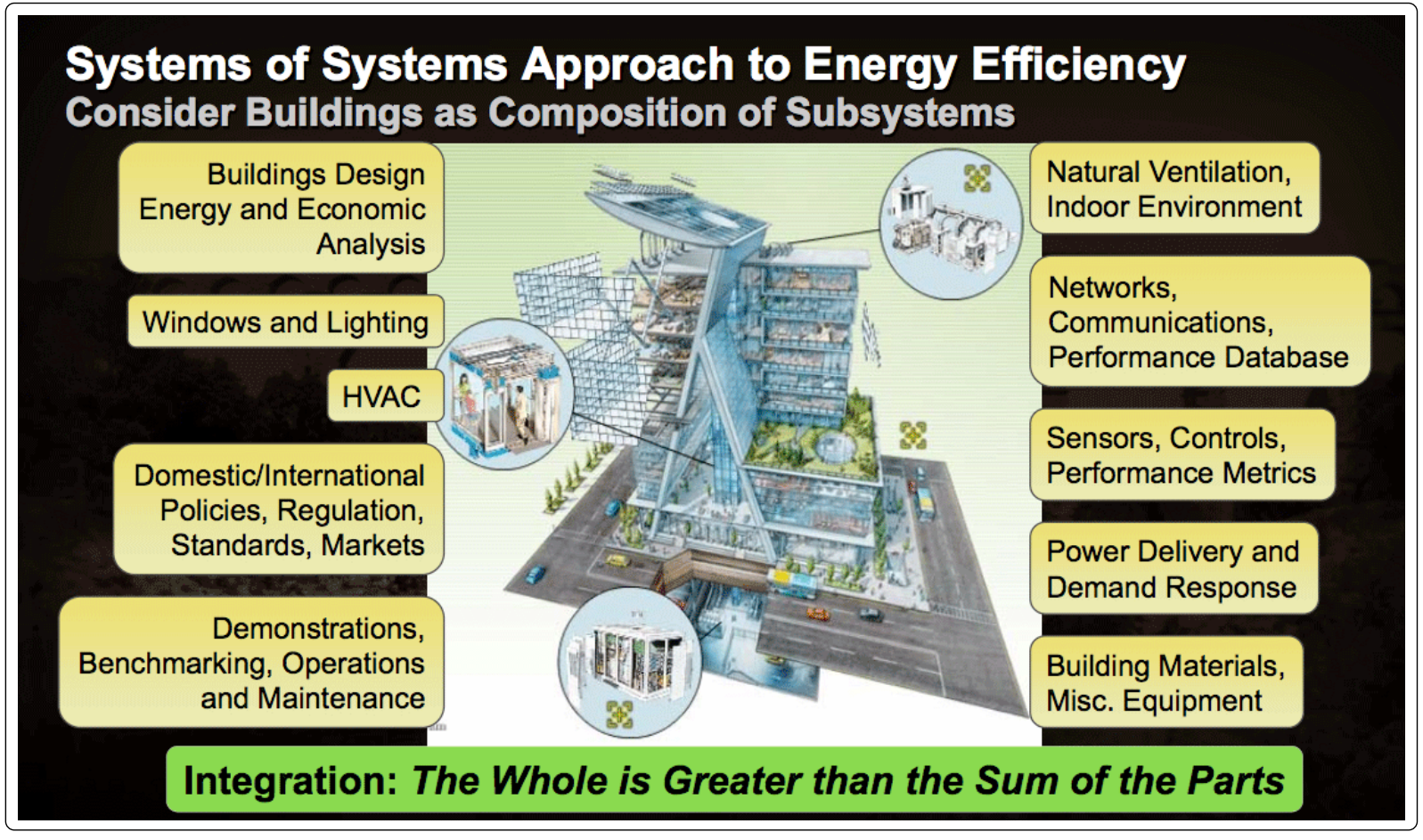
Modern Buildings (Integrated Energy Systems)

Pearl River Tower (2010):

- High performance structure designed to produce as much energy as it consumes.
- Guides wind to a pair of openings at its mechanical floors.
- Wind drives turbines that generate energy for the heating, ventilation and air conditioning systems.
- Openings provide structural relief, by allowing wind to pass through the building.

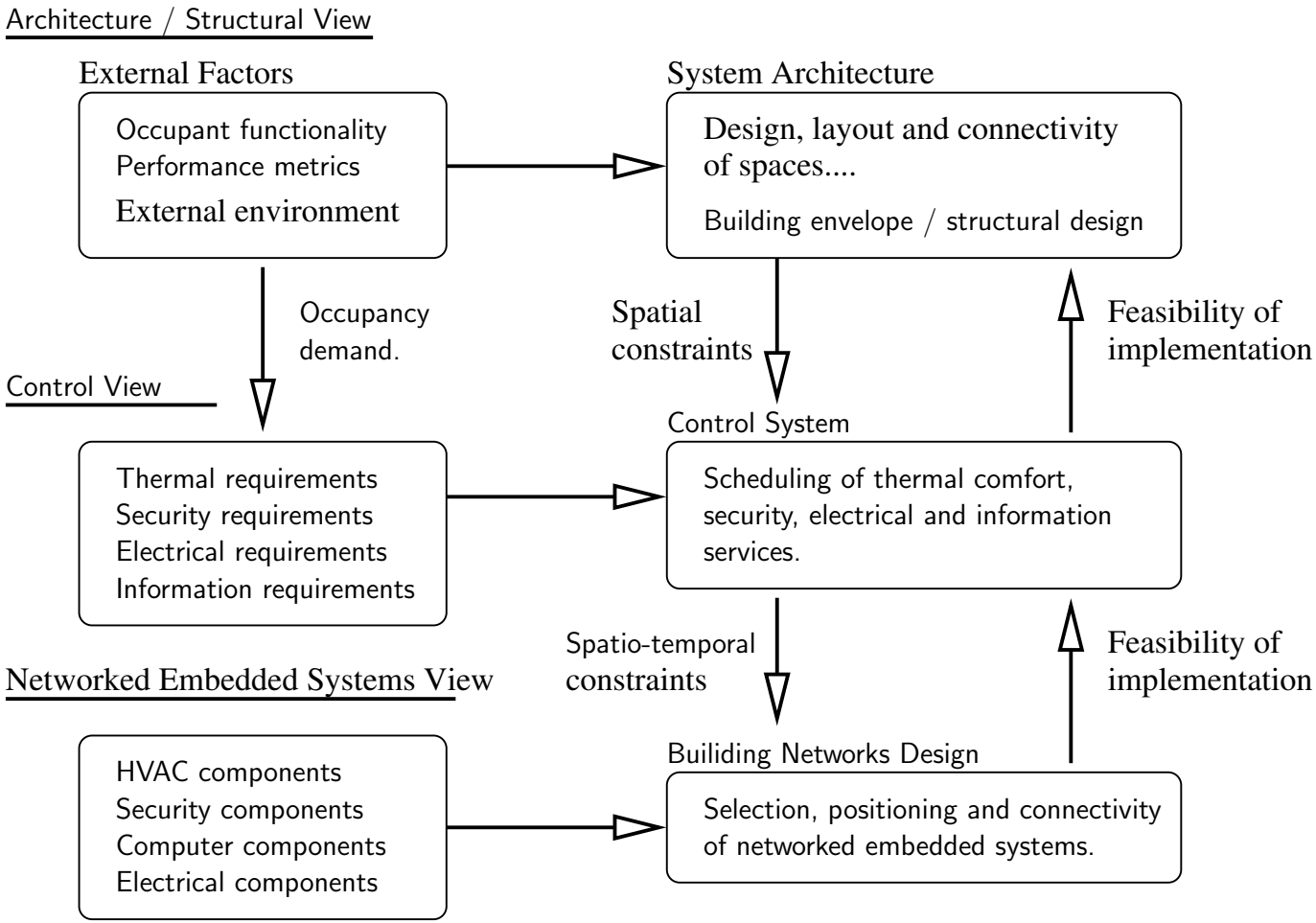


Modern Buildings (Automation Systems Design)



Modern Buildings (Traditional Approach to Design)

Interaction of Muliple-Domains:



Modern Buildings (Platform-Based Design)

Factors Driving Design

Architectural requirements.
Occupancy requirements.
External loads (gravity, thermal, ...)

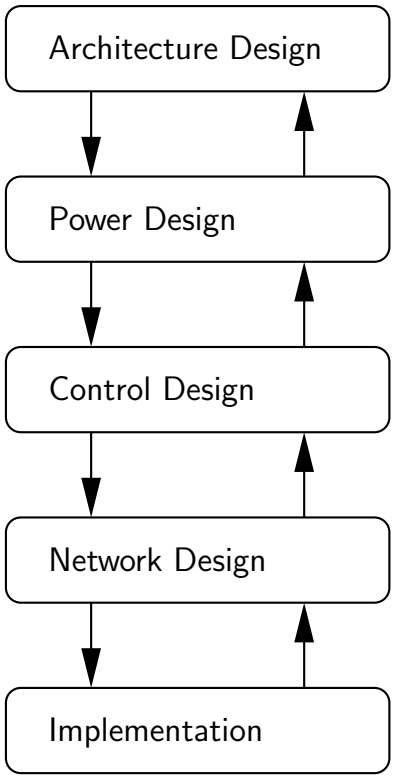
Ventilation requirements.
Energy generation requirements.

Sequence of operations.
Comfort requirements.

Control speed requirements.
Sensor and actuator requirements.

Layout requirements.

Design Flow



Performance

Maximum ventilation.
Maximum power generation.
Cost estimates.

Minimum response time.
Control accuracy.

Maximum available bandwidth.
Maximum computational speed.
Maximum storage size.

Actual ventilation.
Actual power generation.
Actual network speed.
Actual layout constraints.
Actual installation cost.