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HiPerBRIC Whitepaper Summary

LBL and UTRC

July 7-11, 2008

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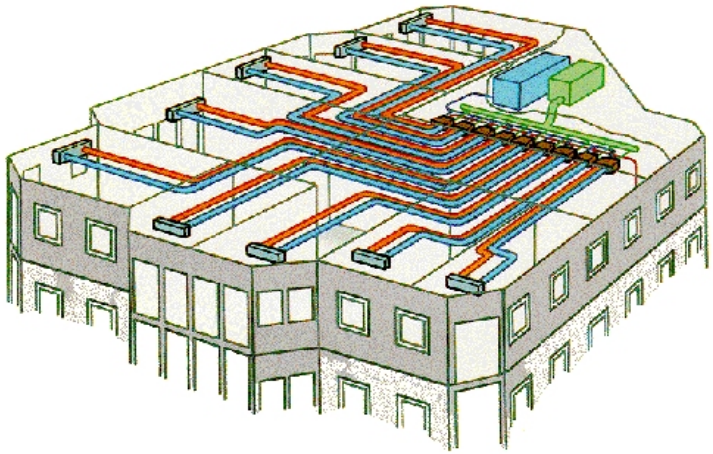
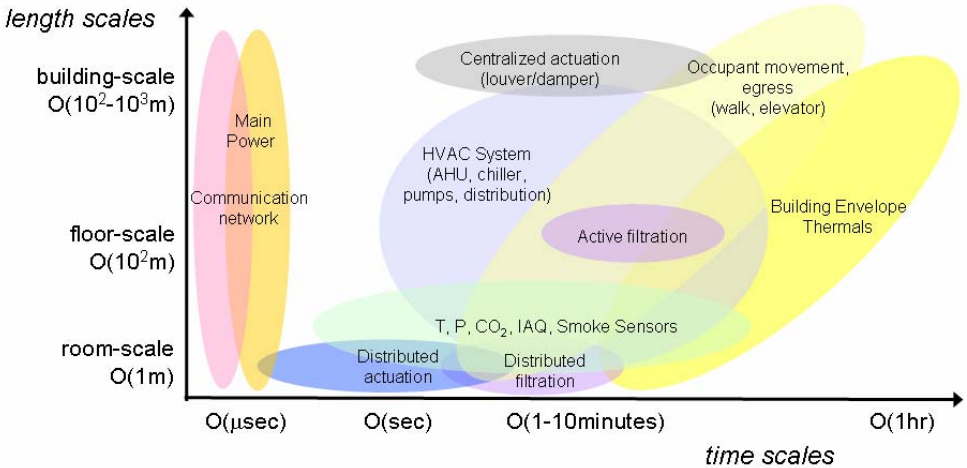
Building Systems Integration Challenge: Complexity

Dynamics at multiple, overlapping, spatial and temporal scales





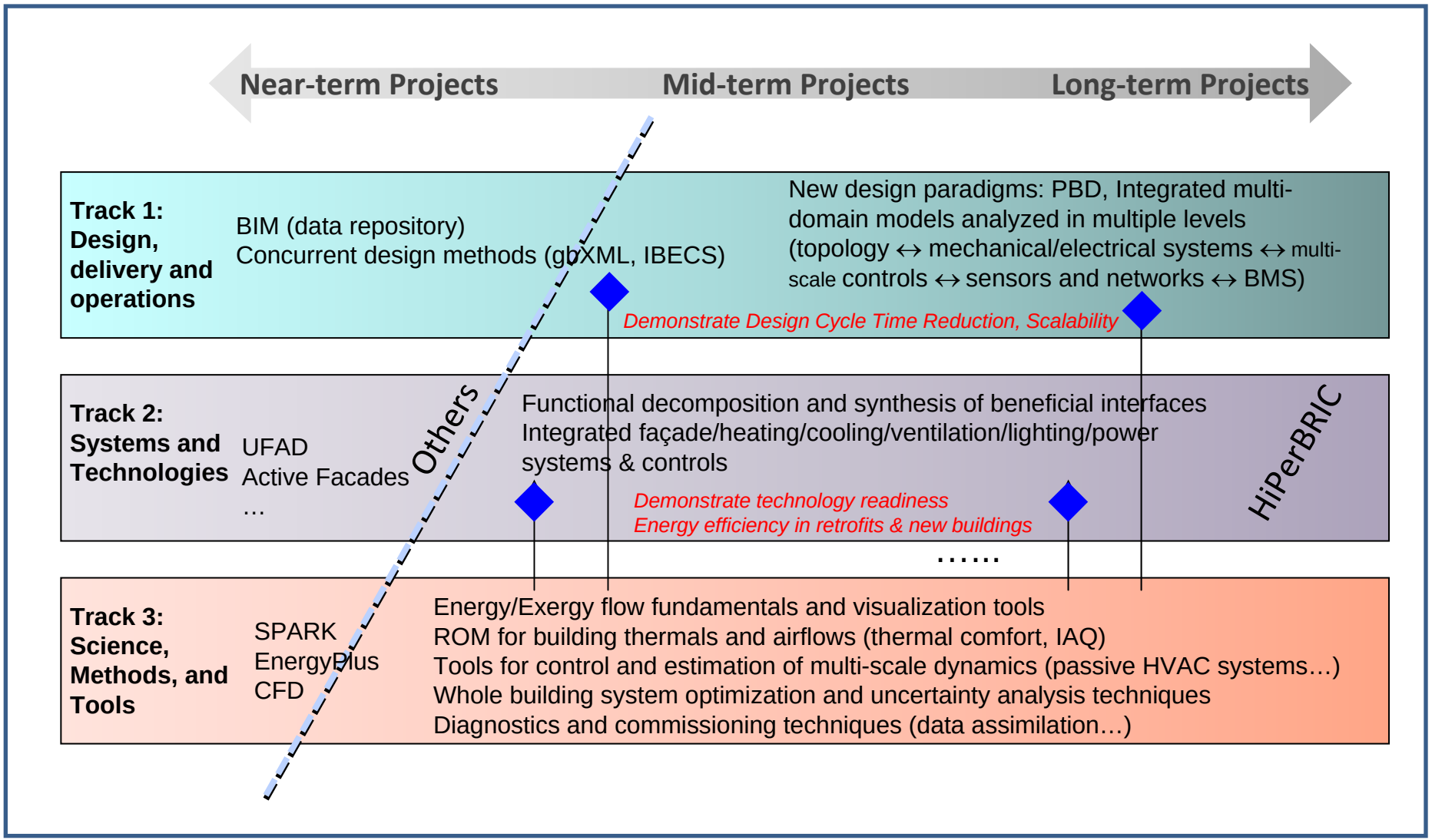
A **whole building system** is a **complex system*** because of the following properties:

- The system components do not necessarily have mathematically similar structures and may involve different scales in time or space;
- The number of components may be large, sometimes enormous;
- Components can be connected in a variety of different ways, most often nonlinearly and/or via a network. Furthermore, local and system wide phenomena may depend on each other in complicated ways;
- The behavior of the overall system can be difficult to predict from the behavior of individual components. Moreover, the overall system behavior may evolve along qualitatively different pathways that may display great sensitivity to small perturbations at any stage.

Summary of Writing

- Gaps identified in current design methodology, process and tools – sequential design process and tools that *do not reflect* operations and end-use
- Needs identified for new paradigms to address building design and delivery process
- Gaps identified in current implementations of integrated systems (understanding of building physics, dynamics and controls and systematic risk reduction)
- Needs identified for tools needed to support scalable design and robust operation of integrated building systems and controls
- Program tracks defined to address gaps and needs
    - Design, Delivery and Operations (*system-level design methodology*)
    - Systems and Technologies (*identification of new system architectures, technology maturation and demonstration*)
    - Science, Methods & Tools (*fundamentals of building science, multi-scale dynamics (thermal, airflows), hierarchical controls, model reduction, uncertainty /sensitivity/optimization analysis, computational science*)

Summary of Writing



Maturation of Methods, Tools & Technologies

Whitepaper Topics and Projects

Framework for Design of Integrated Systems and High Performance Buildings

1. Design of High Performance Green Building
2. Simulation and Verification of “Integrated Solutions” for Energy Efficient Buildings (HVAC & lighting)
3. Synthesis and Optimization of Distributed Control Systems and Networks
4. Demonstration of Integrated Framework for Net Zero Energy Building Design and Synthesis

New Systems and Technologies

Phase I

1. Prototype Technology Maturation Process
2. Mix-mode-ventilation IWBS (Integrated Whole Building Solutions) package
3. Energy microgrids IWBS package
4. Integrated Building Management System for diagnostics & prognostics IWBS package
5. Systems Interoperability IWBS package

Phase II

6. Technology Maturation Process Refinement
7. Future IWBS packages will develop standardized, “low touch” IWBS packages

Science, Methods & Tools: Modeling

1. Building Information Models
2. Design Flow for a Robust Displacement Ventilation System
3. Design of energy-efficient hybrid HVAC systems
4. Occupancy-based energy saving control

Science, Methods & Tools: Computational Science for Design, Optimization and Control of High Performance Buildings

1. Computational Methods for Simulation Based Design
2. Holistic Sensitivity Based Model Reduction and Optimization
3. Physics Based Tools for Whole Building Supervisory Control

Science, Methods & Tools: Advanced Control Methods

1. Theory, Architecture and Algorithms for Building Control
2. Rapid Prototyping Platform for Buildings
3. Diagnostics
4. Control commissioning: Tuning methodology and tools
5. Data assimilation
6. Theory, Architecture and Algorithms for Control over Networks

Assessment of What is Missing in Current Writing

- Physics-based and phenomenological modeling of thermal phenomena enabling integrated building systems (e.g. thermal storage/rejection…)
- Integration of novel “source” technologies with building and systems (e.g. renewables)
- Methods/tools/techniques and technologies for efficient building operation (estimation, diagnostics, self-tuning/adaptation, auto-commissioning)
- Building construction domain
- Architectural engineering domain
- Power distribution networks domain
- Issues associated with standards
- Others? …

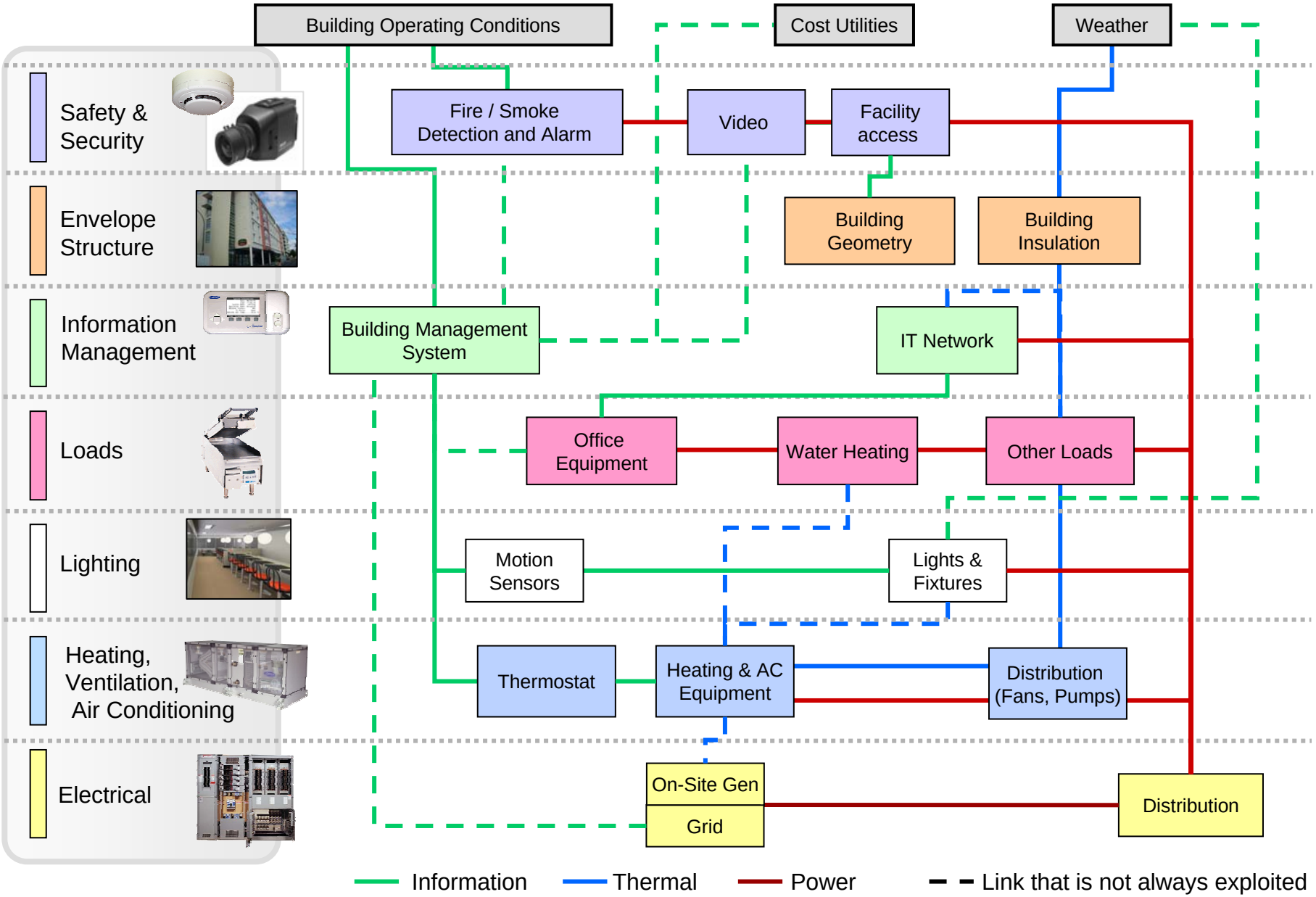
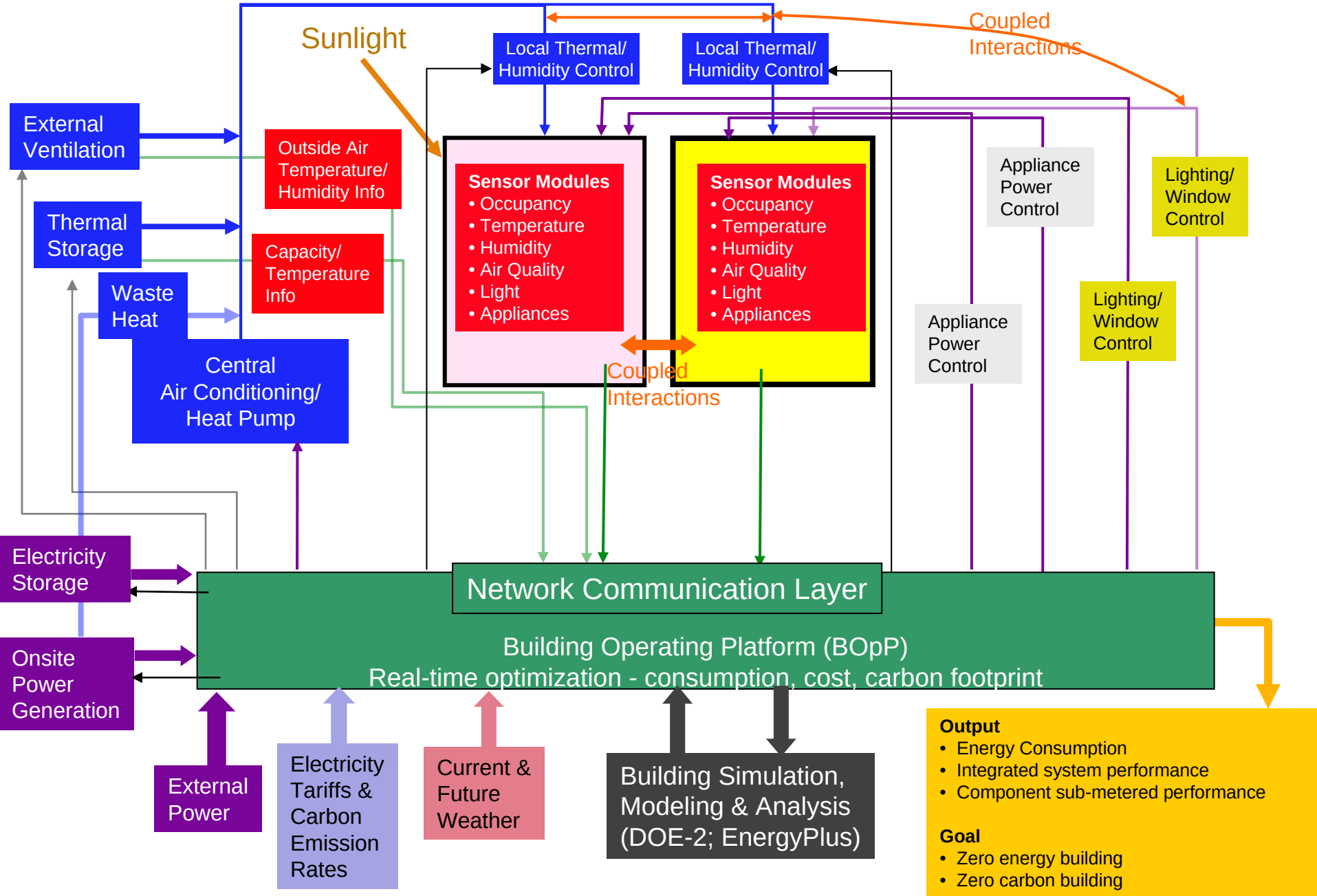
Back up

Objective

Write Whitepaper for R&D Agenda of HiPerBRIC

- Current State and Desired State Where are we now, Where do we want to be?
- What are the key barriers?
- What technical approach do we need to overcome these barriers?
- Can we divide that up in the projects and sub-projects?
- What resources do we need to get there?
- What is the timeline to get there?

HiPerBRIC Technical Scope: Systems of Systems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