Future IT Infrastructure Research Challenges: An HP Labs View

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Agenda

- High-Impact Research Areas for HP Labs
- Intelligent Infrastructure in the Future
- Exascale Datacenter
- Sustainable Design
- Conclusions

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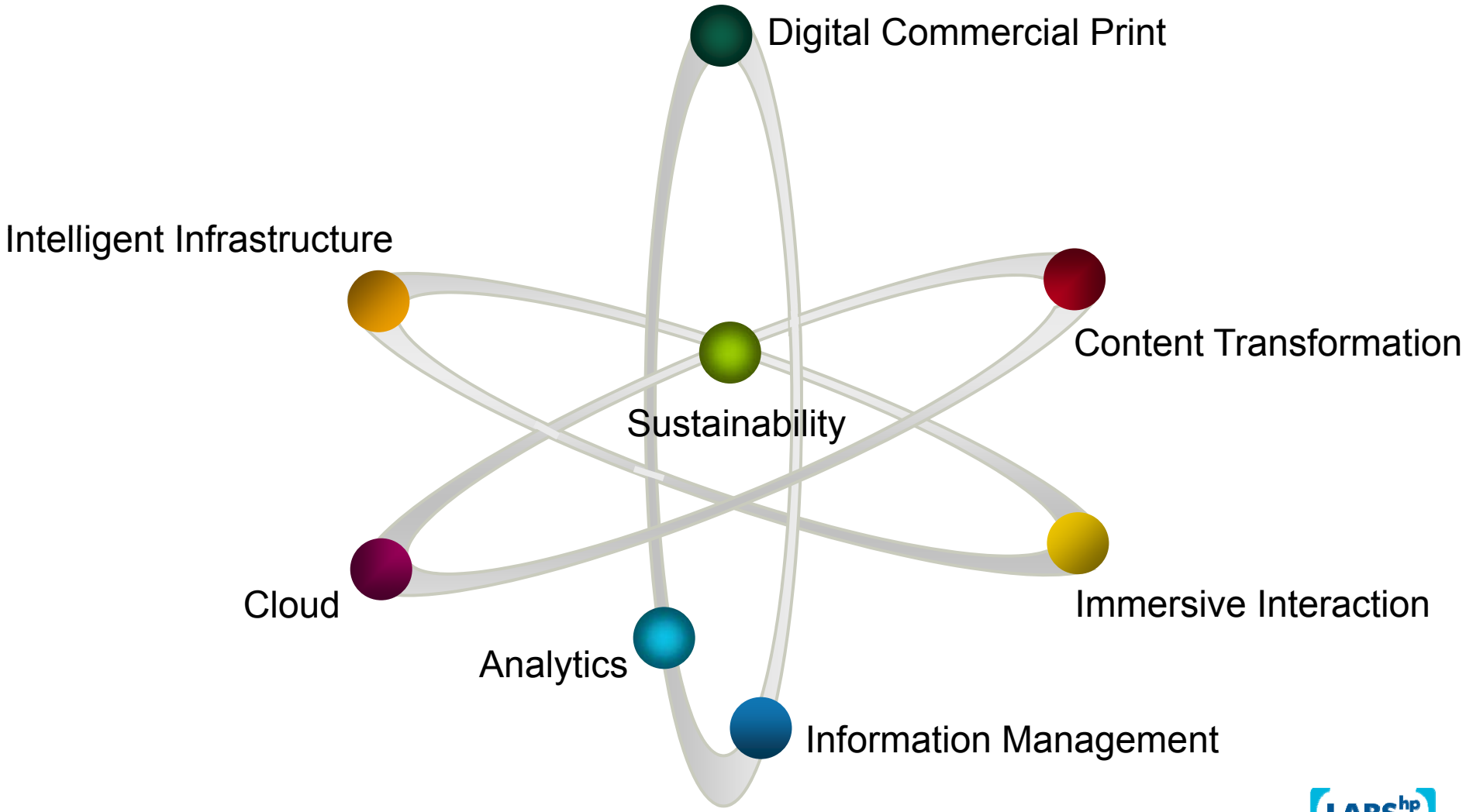
High-Impact Research Areas

The next technology challenges and opportunities



Intelligent Infrastructure

End state: Capture more value via dramatic computing performance and cost improvements

HP Labs' research contribution: Radical, new approaches for collecting, storing and transmitting data to feed the exascale data center

Next-generation Data Centers
Exascale, photonic interconnects, sustainable

Networking
Open, flexible, programmable wired and wireless platform

Next-generation Storage
Cloud-scale, dynamic, secure

Non-volatile Storage
Memristor

CeNSE
Nano-scale sensors creating a Central Nervous System for the Earth

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Next-generation Data Centers

1000x gain in performance

Research contribution

- Exascale: Dramatically more efficient data centers designed across components, interconnects, power & cooling, virtualization, management, and software delivery
- Photonics: Replace copper with light to transmit data

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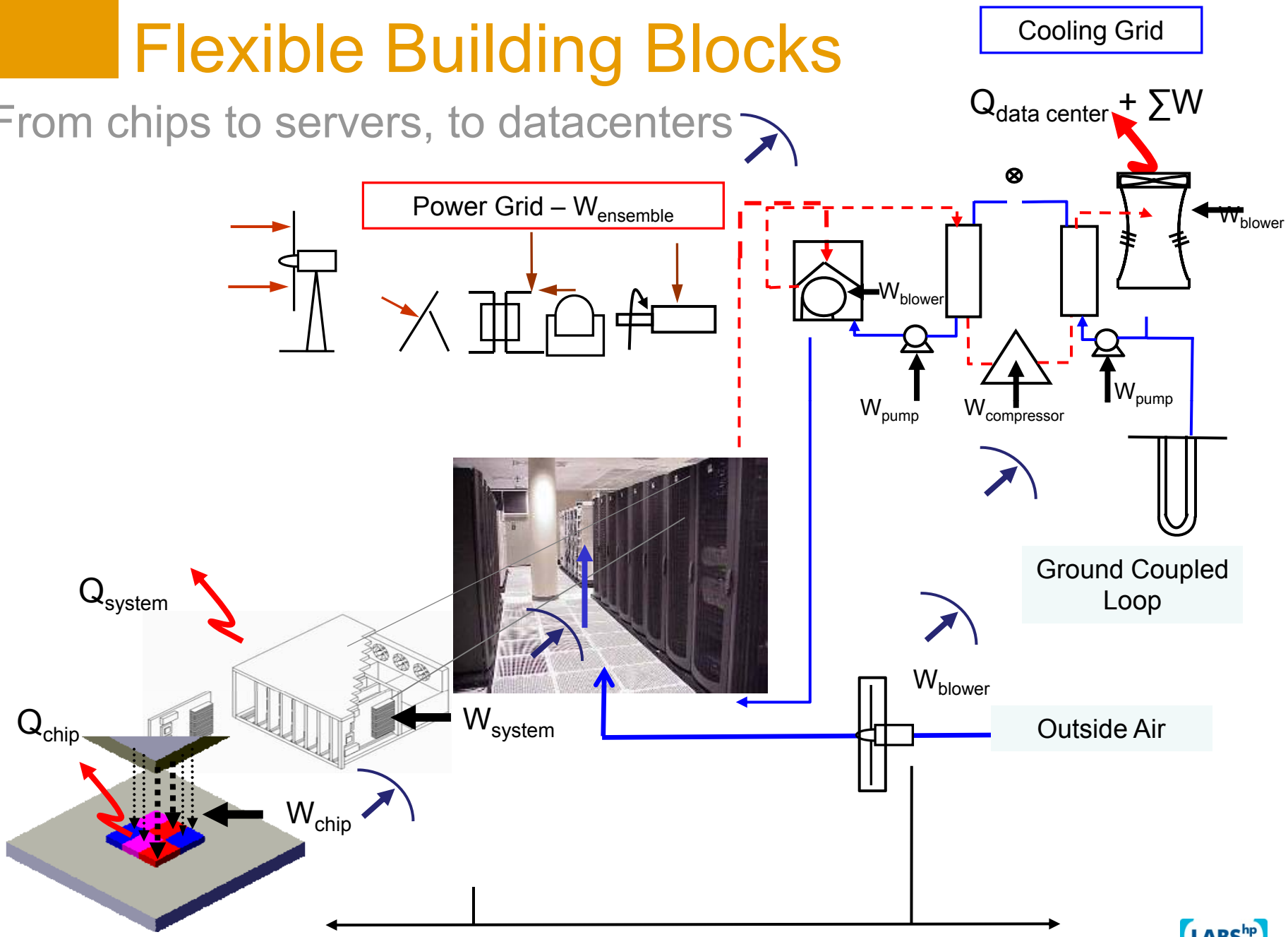
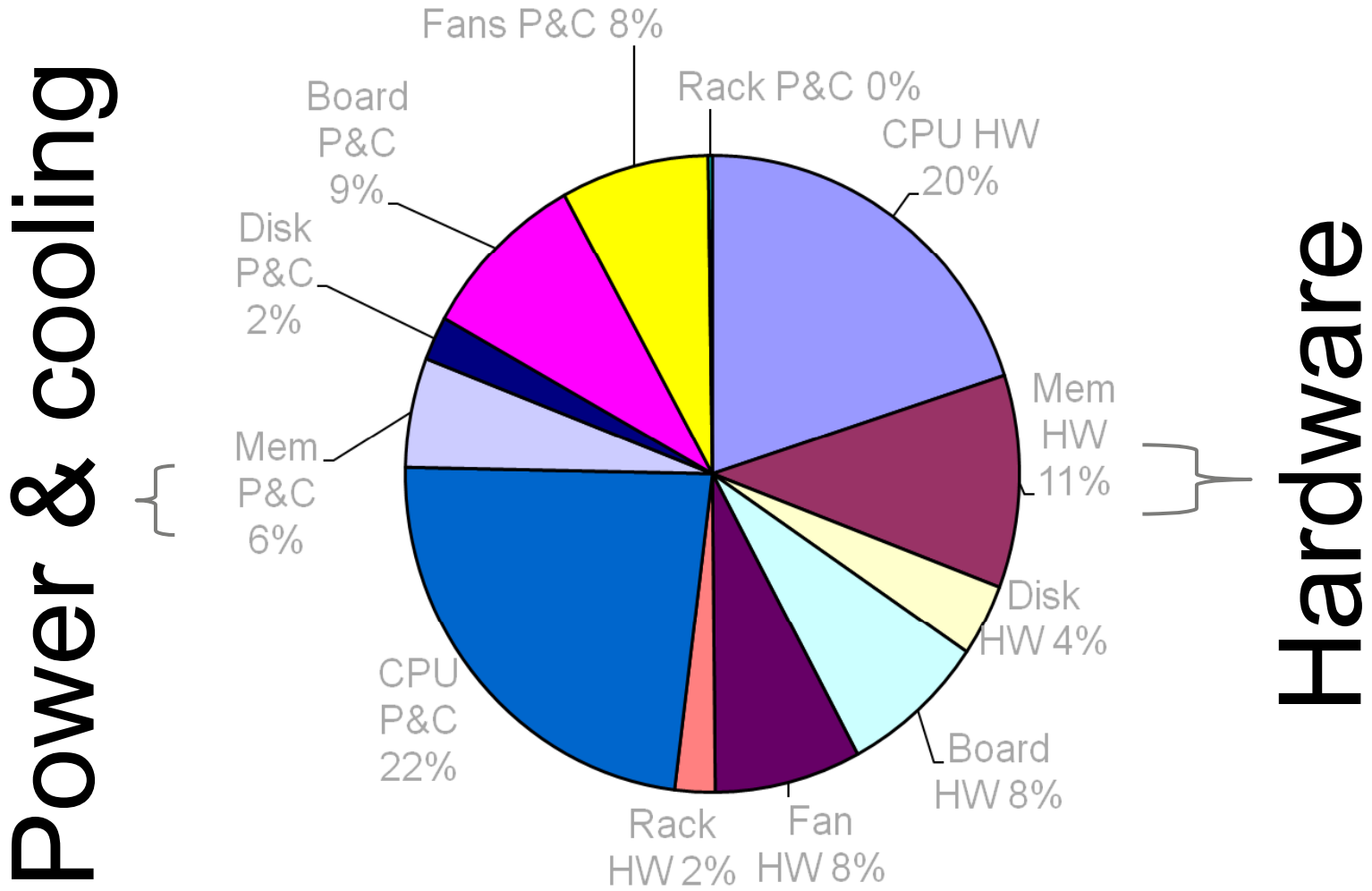
Flexible Building Blocks

From chips to servers, to datacenters



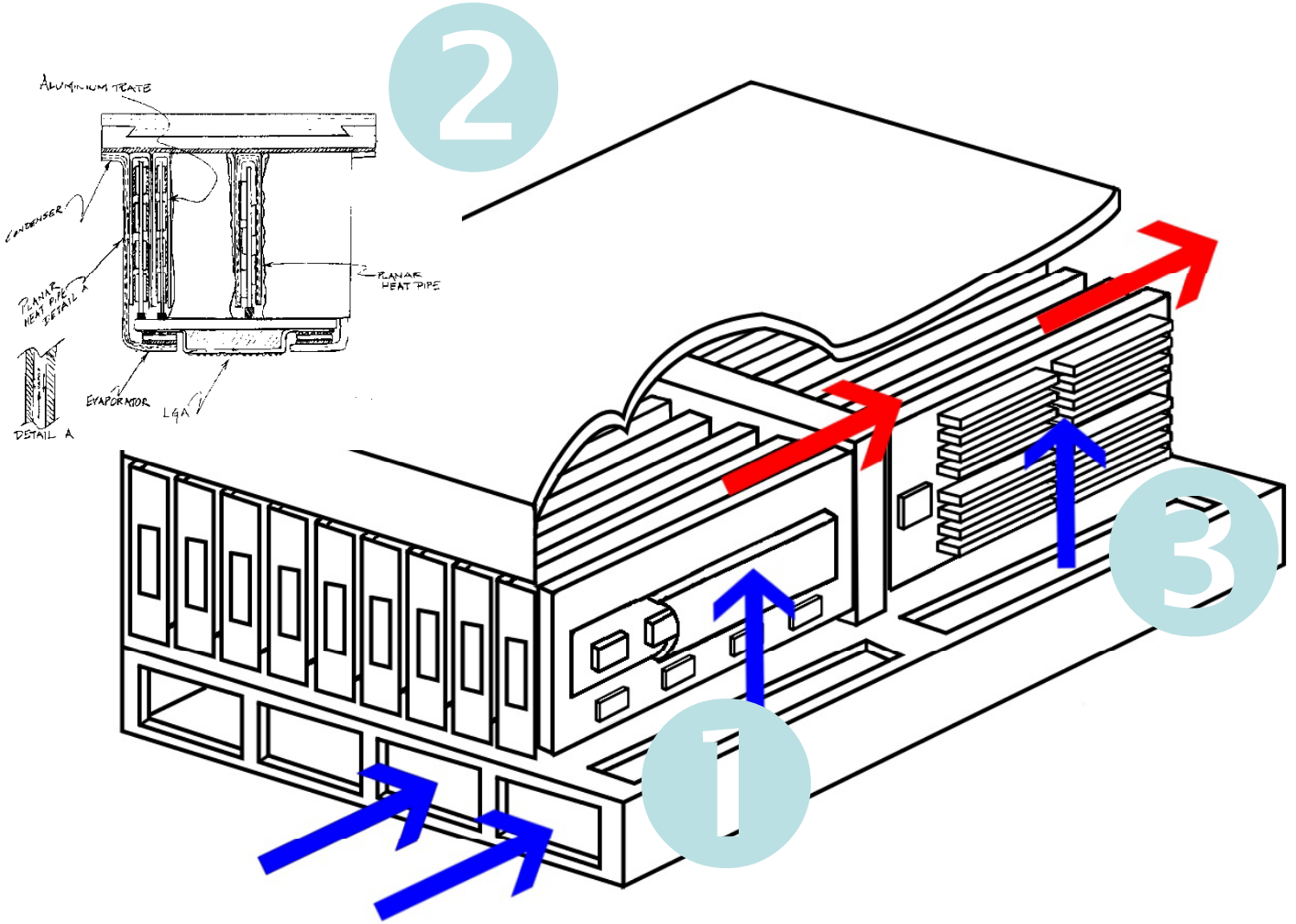
Microblades and Megaservers

Inefficiencies in the cloud

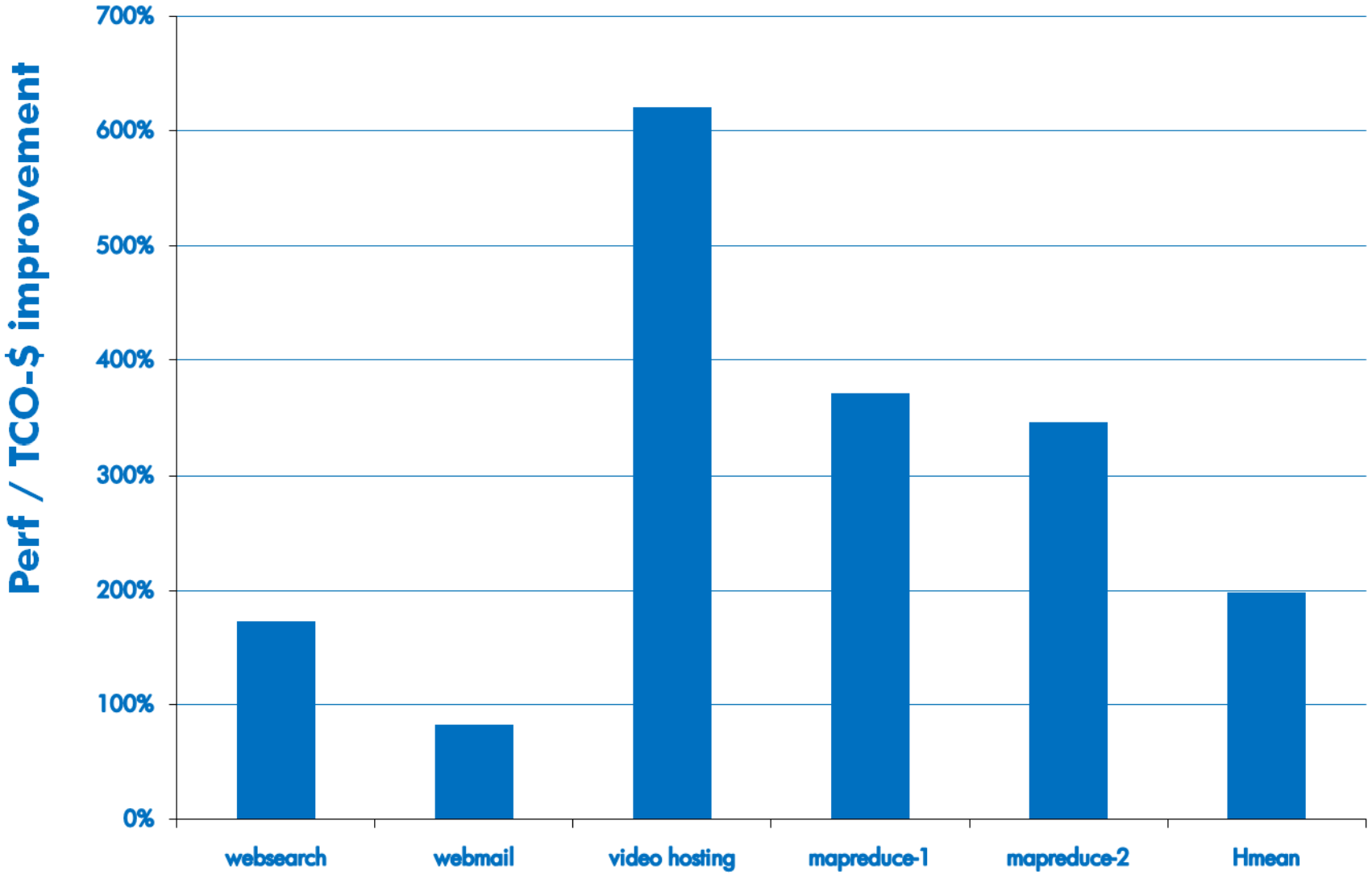


Disaggregation

Efficient Building Blocks



2X performance/$



Photonic Interconnects

Use of light for data communication

- Exponentially increase bandwidth (10^4) with less material and complexity at lower power
- Short-term: Optical Bus
  Replace the backplane in a server rack
- Mid-term: Inter-chip Nanophotonics
  Connect chips in a blade server
- Long-term: Intra-chip Nanophotonics
  Partner with chip manufacturers

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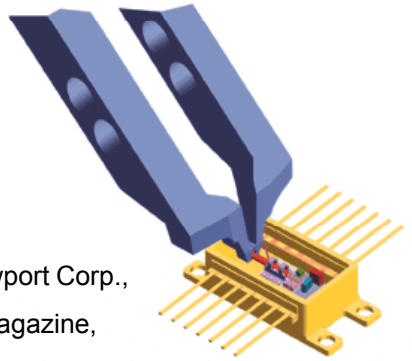
Integrated Photonics

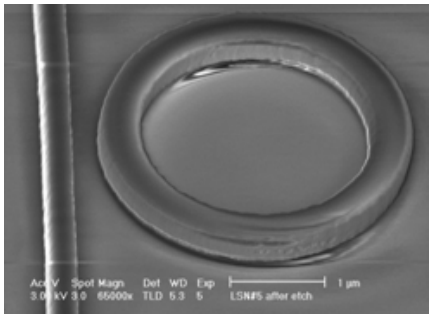
What are integrated photonics?

- The 2000 telecom bubble based on discrete optics
  - Pre-'Noyce/Kilby' era for optics
  - Components measured in millimeters
  - Hand alignment / labor intensive
  - Expensive and not scalable



Source: Newport Corp., Assembly Magazine, September 2001

- Our research is integrated photonics
  - post-'Noyce/Kilby' era for photonics
  - Components are a few micrometer
  - Manufacture many millions per die
  - New discoveries in physics + architectures
  - Photonic crystals, negative index materials
  - Plasmonics



HPL resonator

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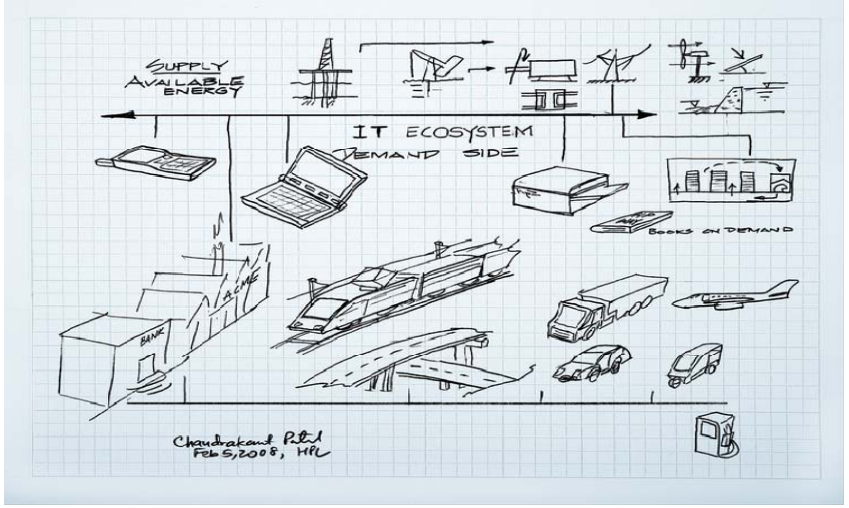
Sustainable Data Center

Reduce data center costs on the bottom line and the environment

- Reduce total cost of operation of a data center by 50% and carbon footprint by 75%, while meeting Quality of Service goals
- Data center modeling, synthesis and optimization
- Real-time management of data center environment
- Real-time management of service application instances



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Industry Challenge

Create technologies, IT infrastructure and business models for the low-carbon economy

IT industry

2%

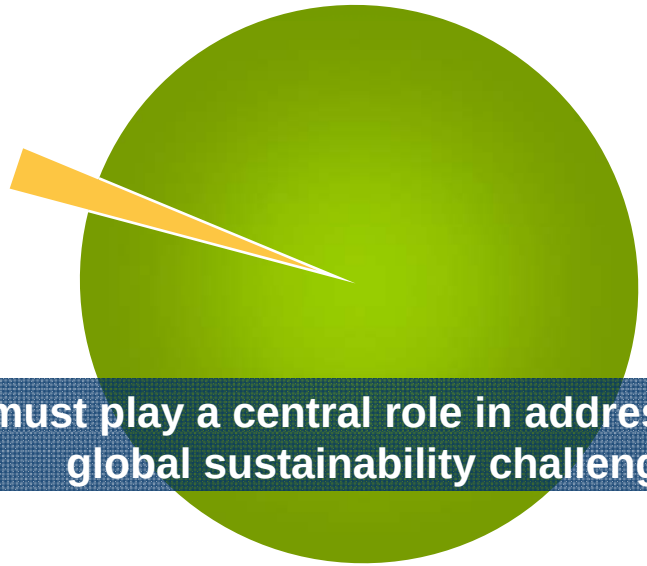
Total carbon emissions

The rest of the global economy

98%

As much as the aviation industry

Projected to double by 2020



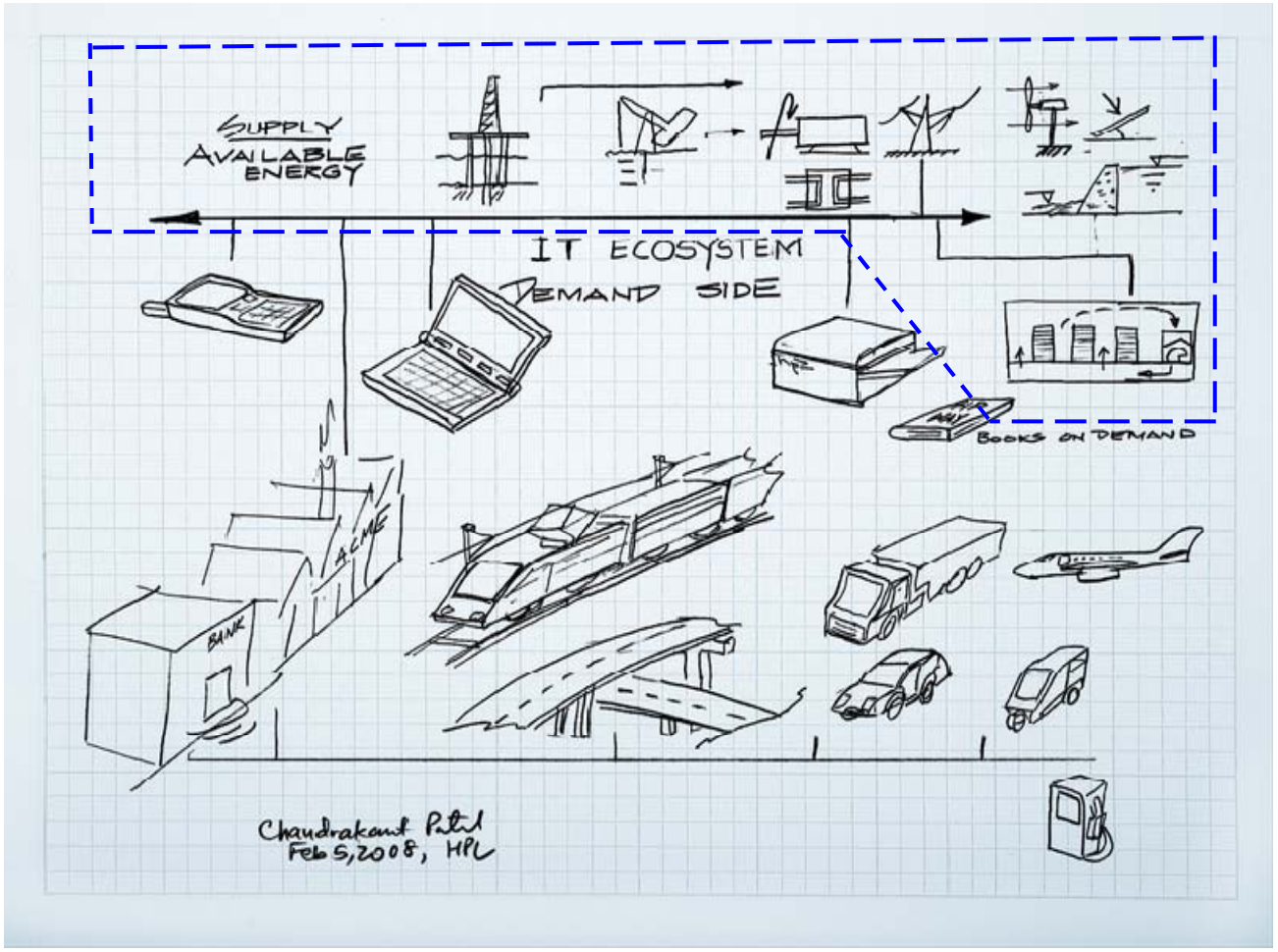
IT can play a role in reducing this impact

To do so, IT solutions must take a lifecycle perspective

IT must play a central role in addressing the global sustainability challenge.

Role of the IT Ecosystem

Data centers at the hub



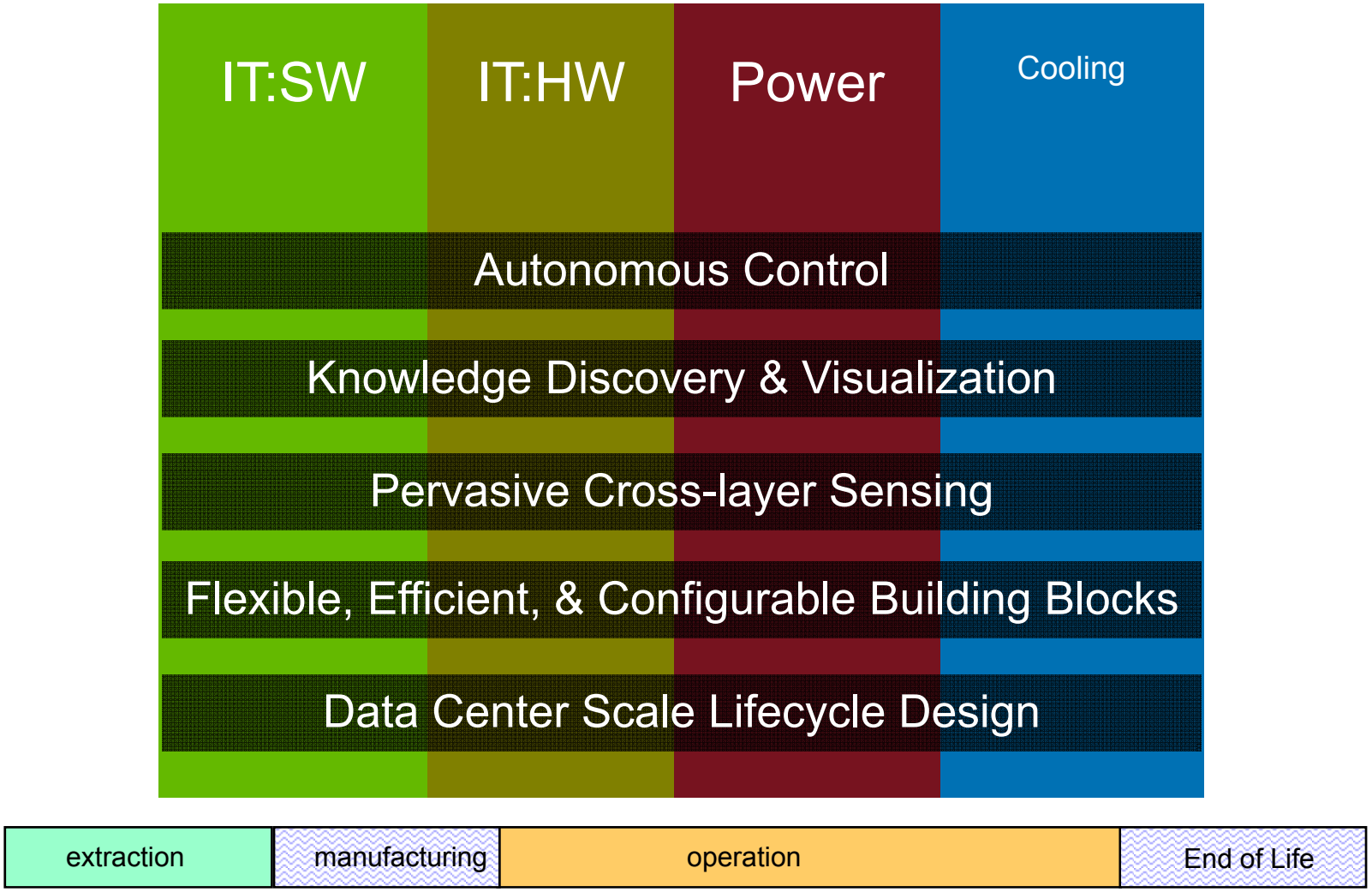
Sustainable Data Centers enabled by supply and demand side management of power, cooling and IT resources

Supply & Demand Side Management

- Supply Side:
  - Design of physical infrastructure with focus on lifecycle engineering and management, and the available energy required to extract, manufacture, operate and reclaim components;
  - Utilization of local resources to minimize destruction of available energy in transmission, and construction of transmission infrastructure.
- Demand Side:
  - Provisioning data center resources based on the needs and service level agreement of the user through use of flexible building blocks, pervasive sensing, knowledge discovery and policy based control

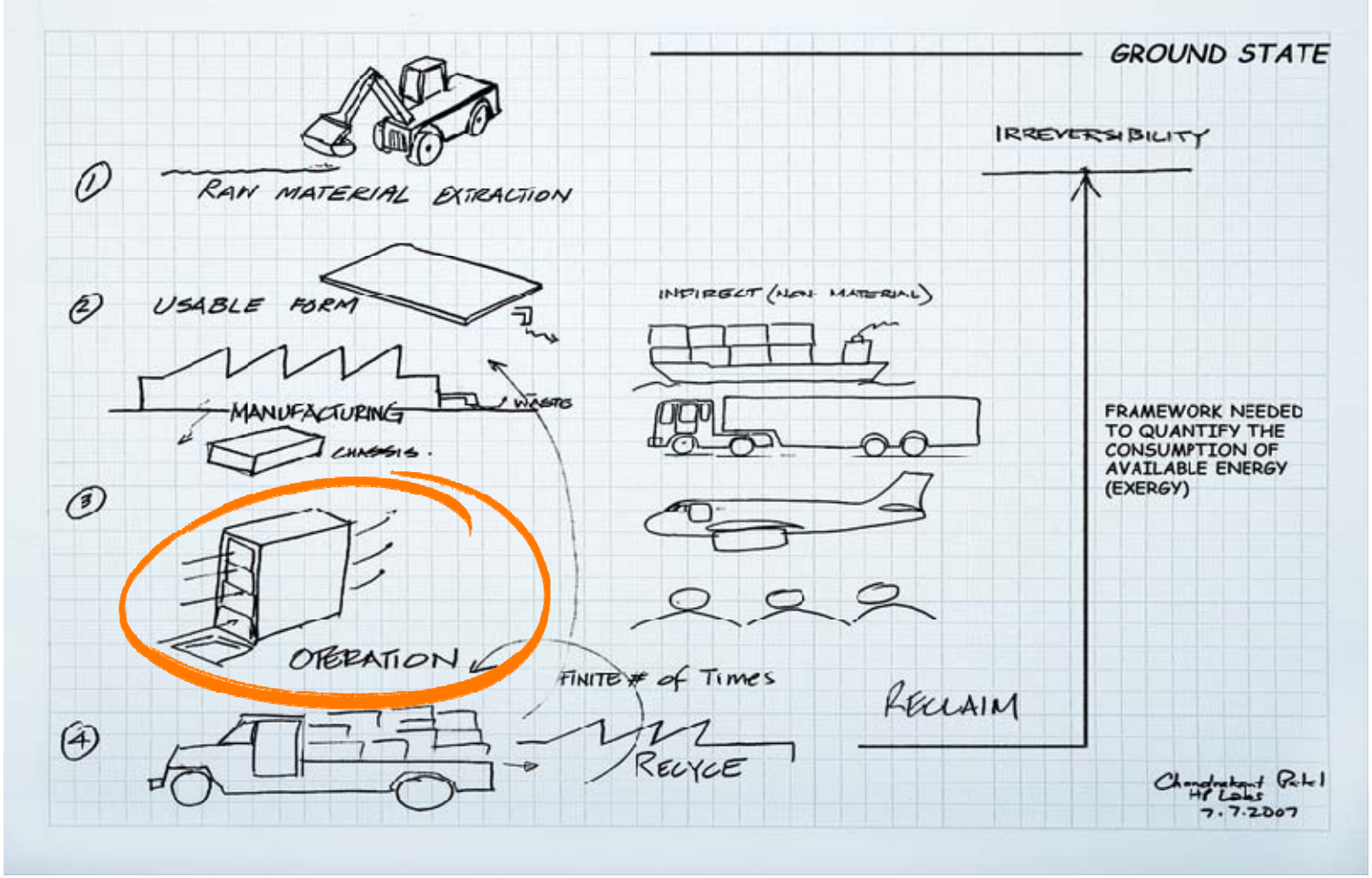
Sustainable Data Center

Key Elements



Lifecycle Design

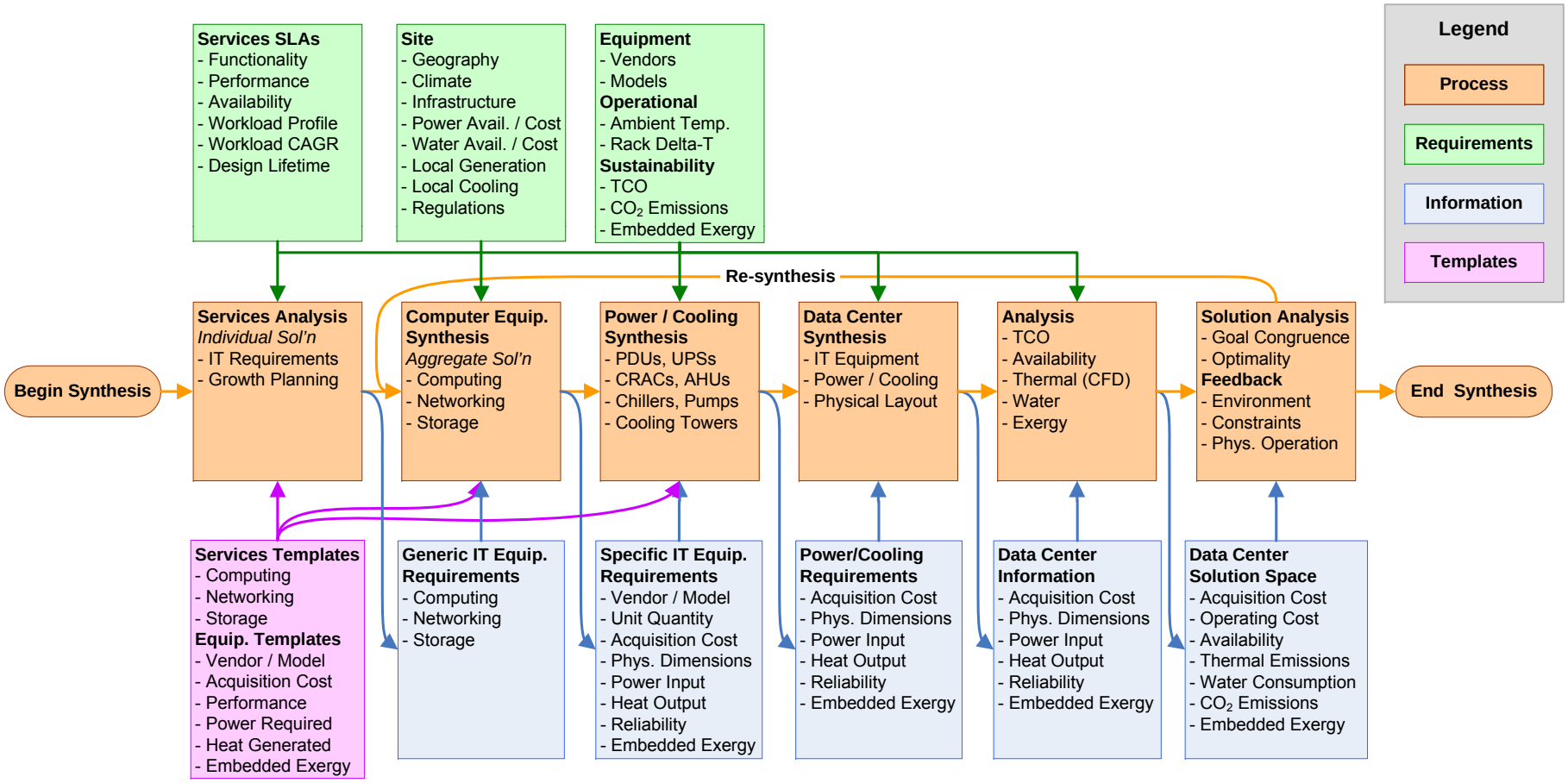
extraction	manufacturing	operation	End of Life



Lifecycle Design through Data Center Synthesis

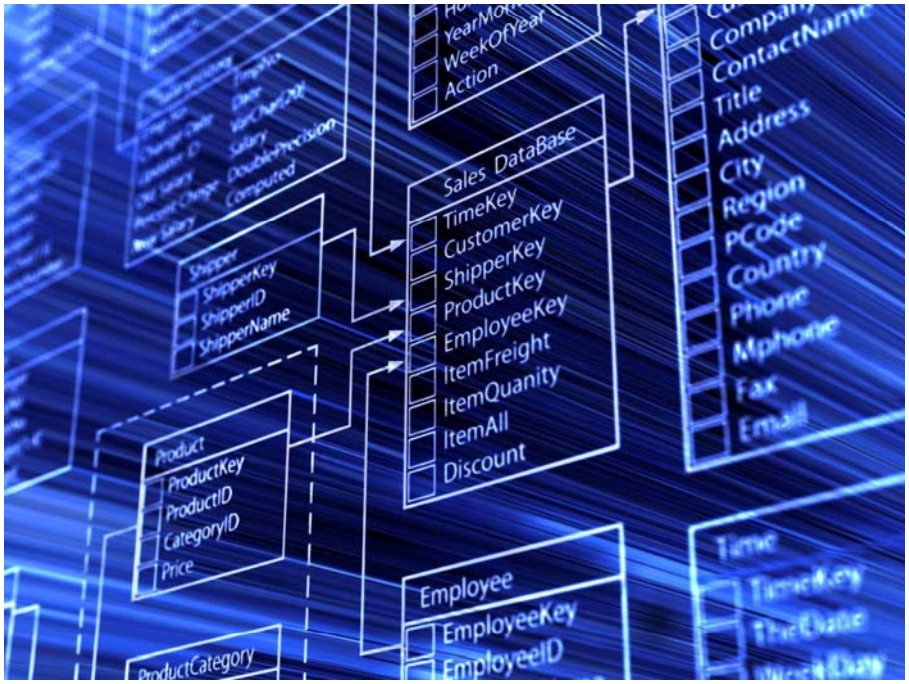
Automated design of datacenters based on lifecycle considerations

Synthesis Process Flow



OpenNet

Programmable networks



- Open, flexible, wired and wireless network platform to enable rapid introduction of new functionality
- End-to-end quality of service, reliability, security, mobility and management
- Scalable and energy-efficient data center networks

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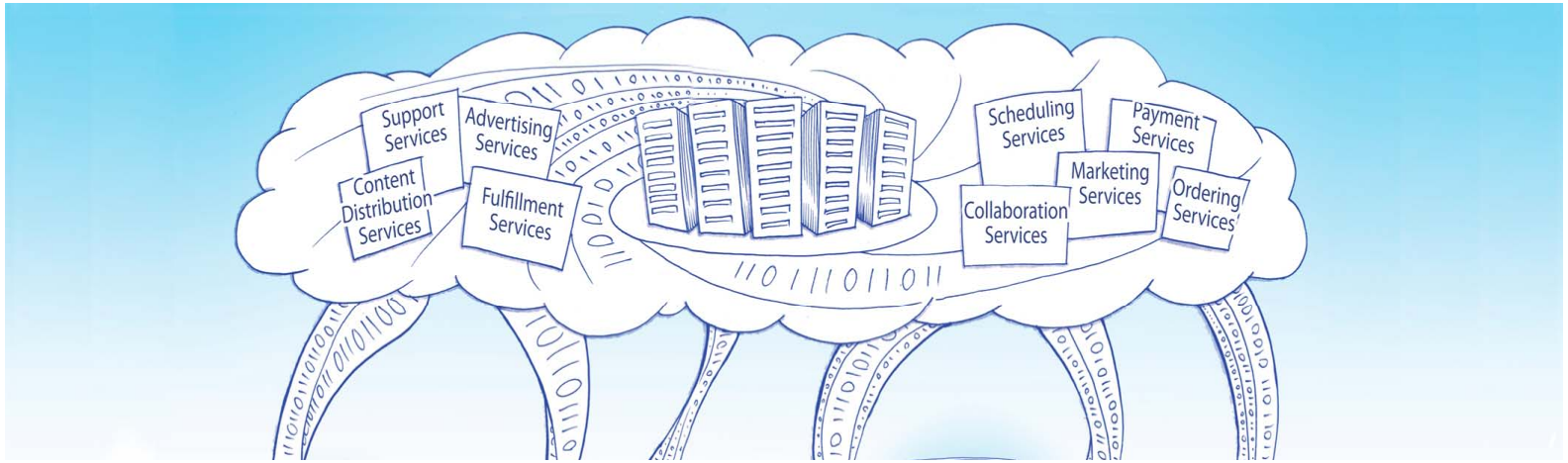
Next-generation Storage

Cloud-scale storage for the enterprise



- Greater than 100 petabytes of capacity with enterprise-class reliability, availability, security
- Less than 10 percent over commodity cost
- Ability to handle data center failures
- Ability to manage multi-tenancy

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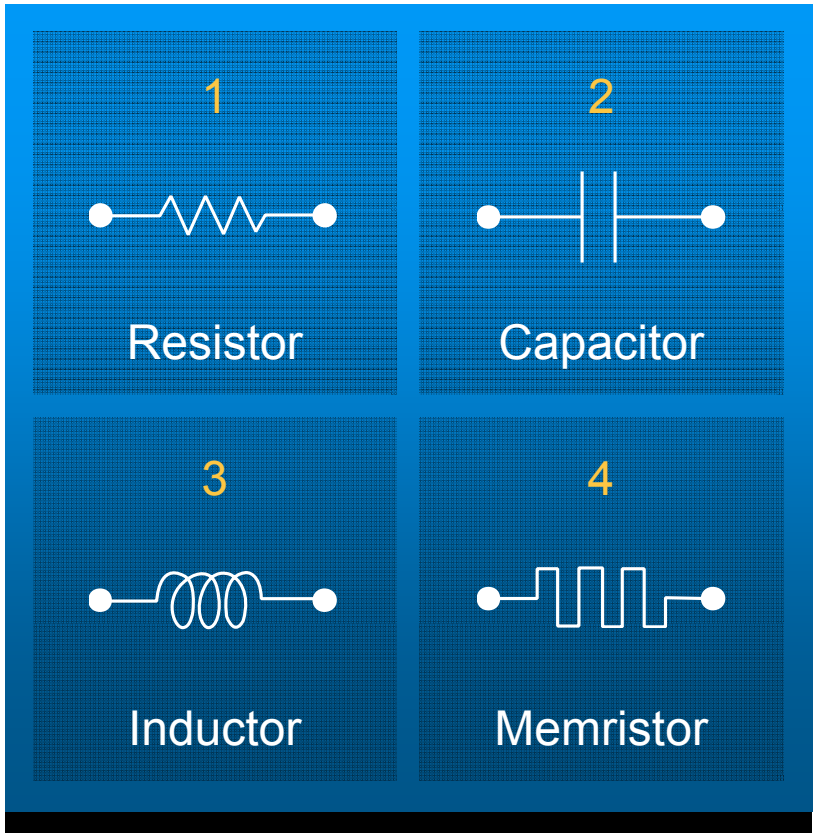
Non-volatile Storage

Memristor: A resistor with memory



Research contribution

- 2006: HP Labs discovers fourth fundamental element of electronic circuitry
- 2008: Development ready
- Fashioned into non-volatile, solid-state memory, could replace DRAM and hard drives
- Combined into crossbar latches, could replace transistors

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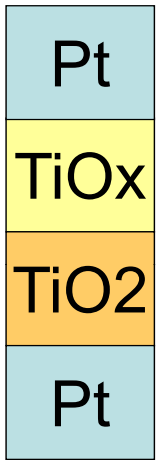
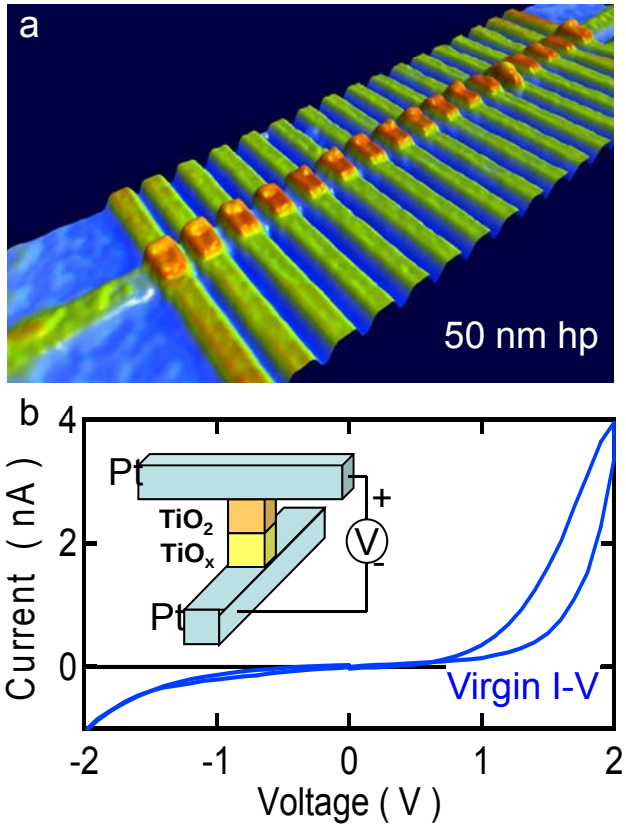
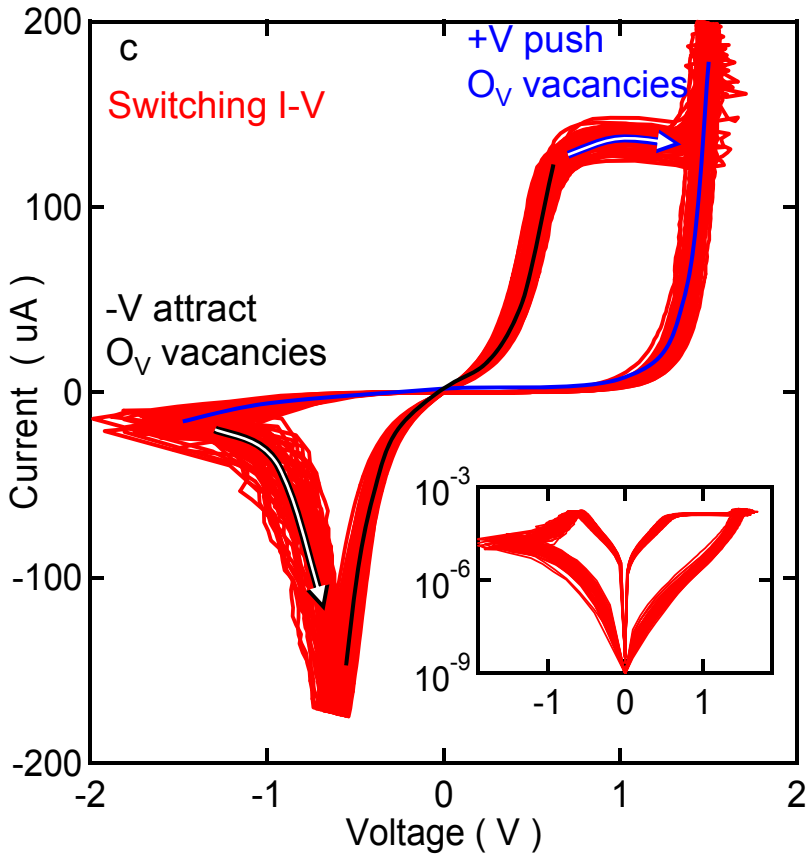
Memristor

Potential to revolutionize electronics







Structurally simple and easy to fabricate

Switches in nanoseconds

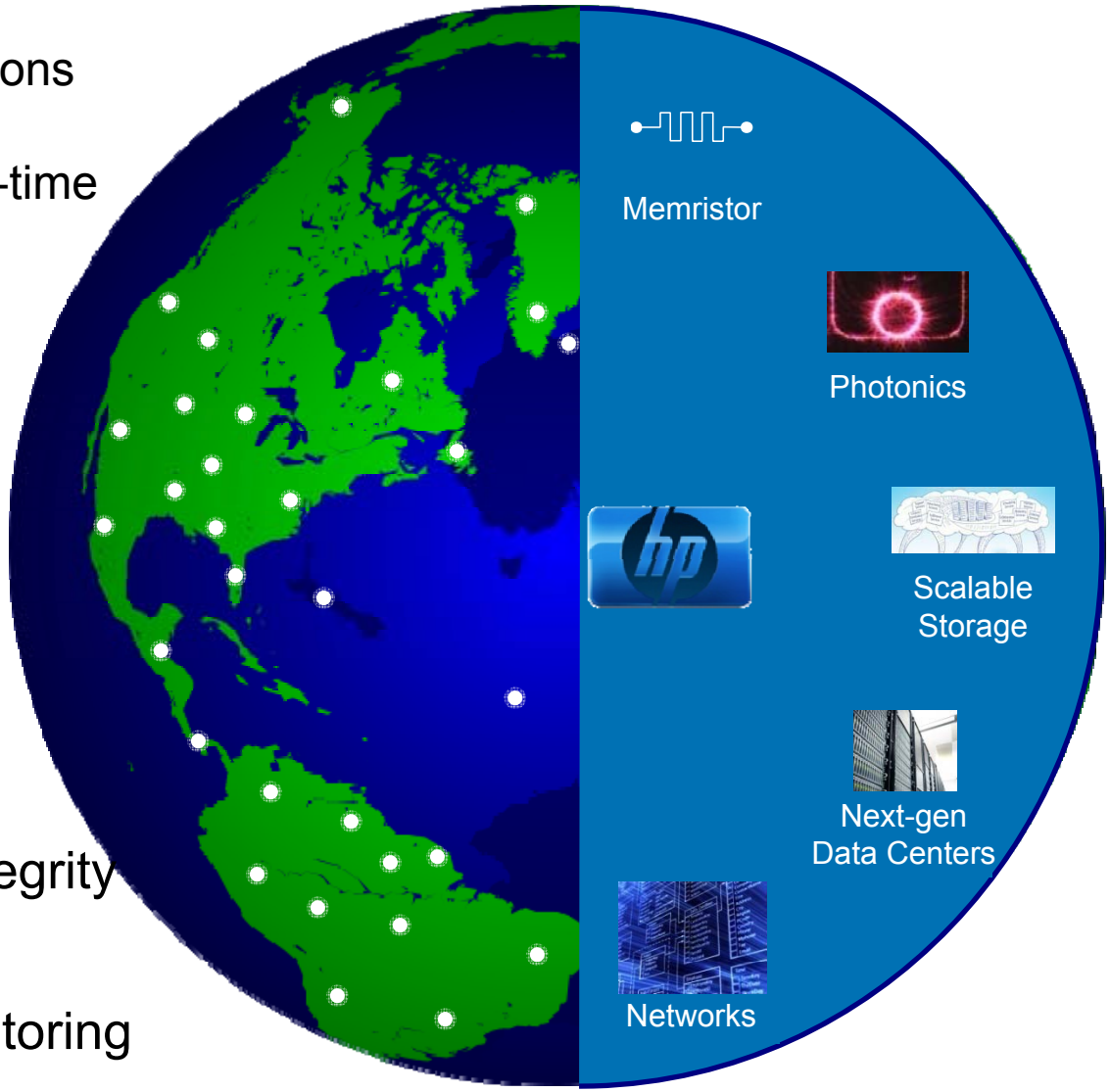
Many year lifetimes

[redacted]

CeNSE

Central Nervous System for the Earth

Networks of billions of nano-scale sensors for real-time monitoring…



Actionable Information:

- Seismic oil exploration
- Merchandise tracking
- Structural integrity
- Energy use
- Climate monitoring

Intelligent Infrastructure:

Ability to tame and exploit 1000x data

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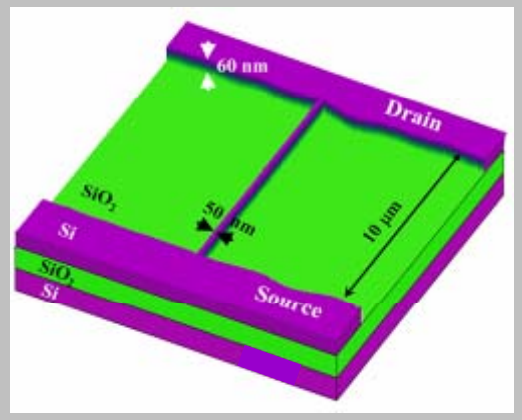
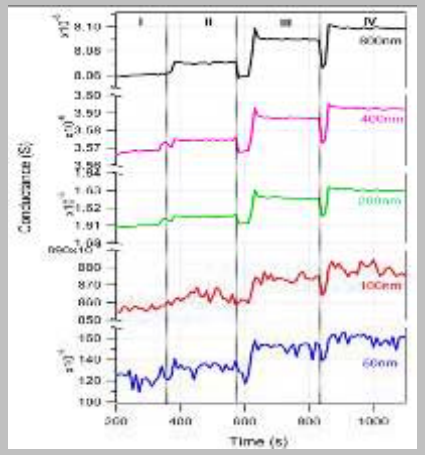
Nano Chem/Bio Sensor

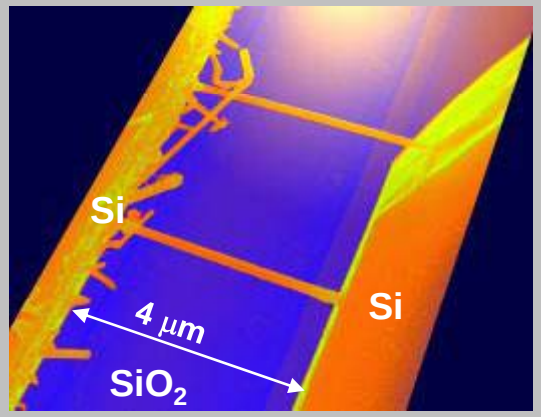
Top-down fabricated SiNW

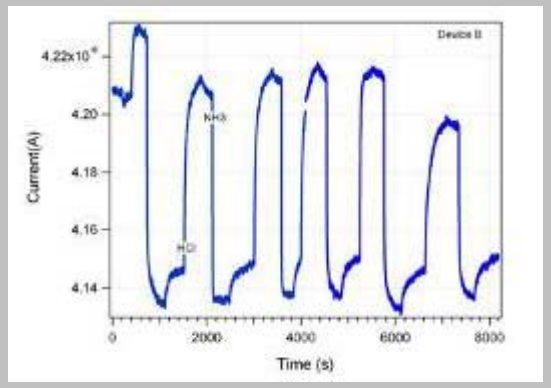




DNA detection 20 pM

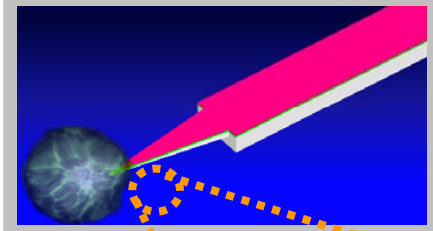
Bottom-up CVD grown SiNW

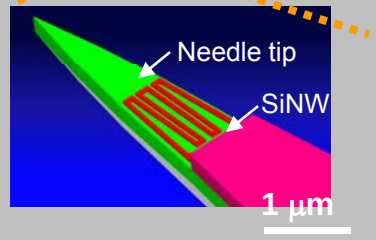


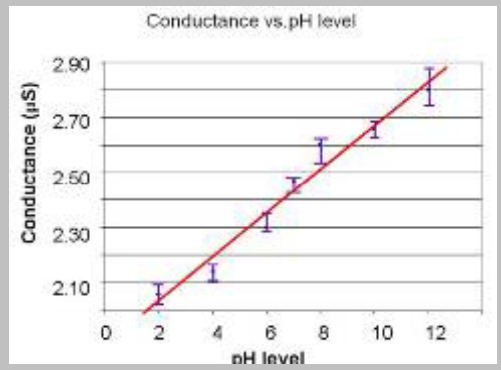


Gas detection: Ammonia 600 ppm

SiNW integrated on micro-needle







Local environmental sensing

Conclusion

In the past, EDA research focused on chips…

In the future, we need to look at entire systems…

- Sensors, networks, datacenters
- Electronics and photonics
- Performance and sustainability

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