Electrical Engineering – Again

Lothar Thiele

Overview

- Electrical Engineering
- Challenges
- Opinions

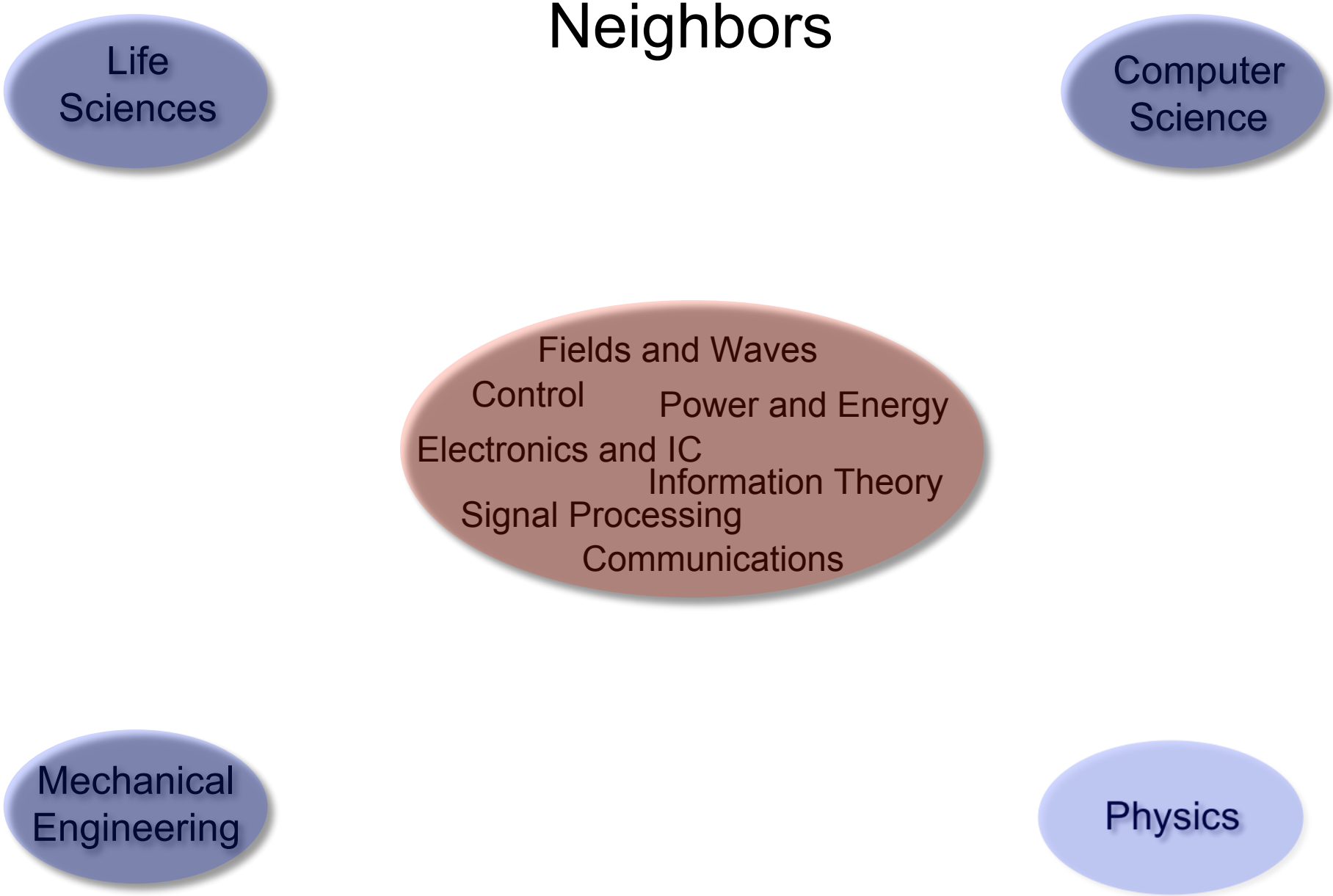
Overview

- ***Electrical Engineering***
- Challenges
- Opinions

EE Core

Fields and Waves
Control
Power and Energy
Electronics and IC
Information Theory
Signal Processing
Communications

Neighbors


Life Sciences
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Fields and Waves
Control
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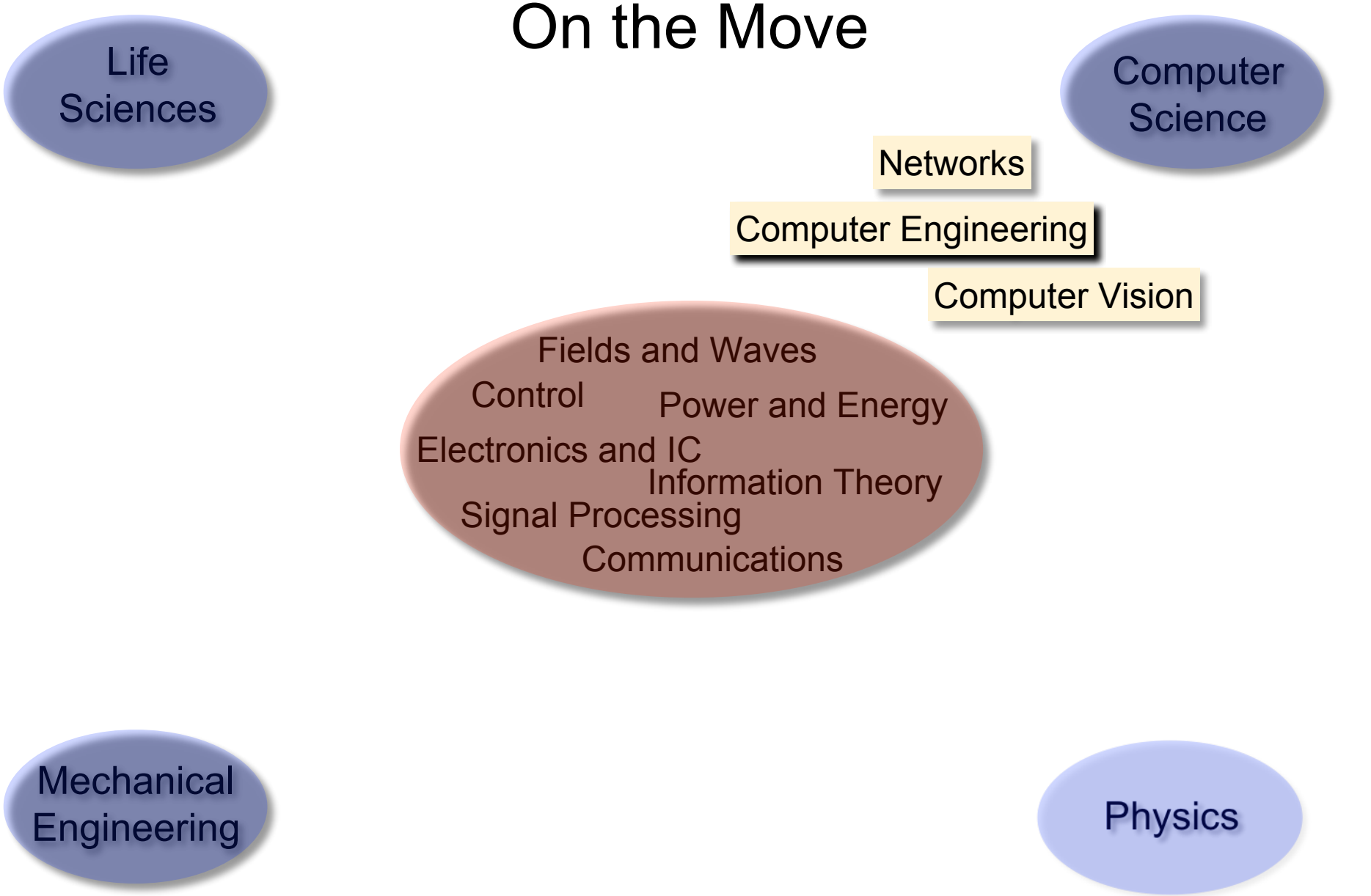
Information Theory
Signal Processing
Communications
Mechanical Engineering
Physics

On the Move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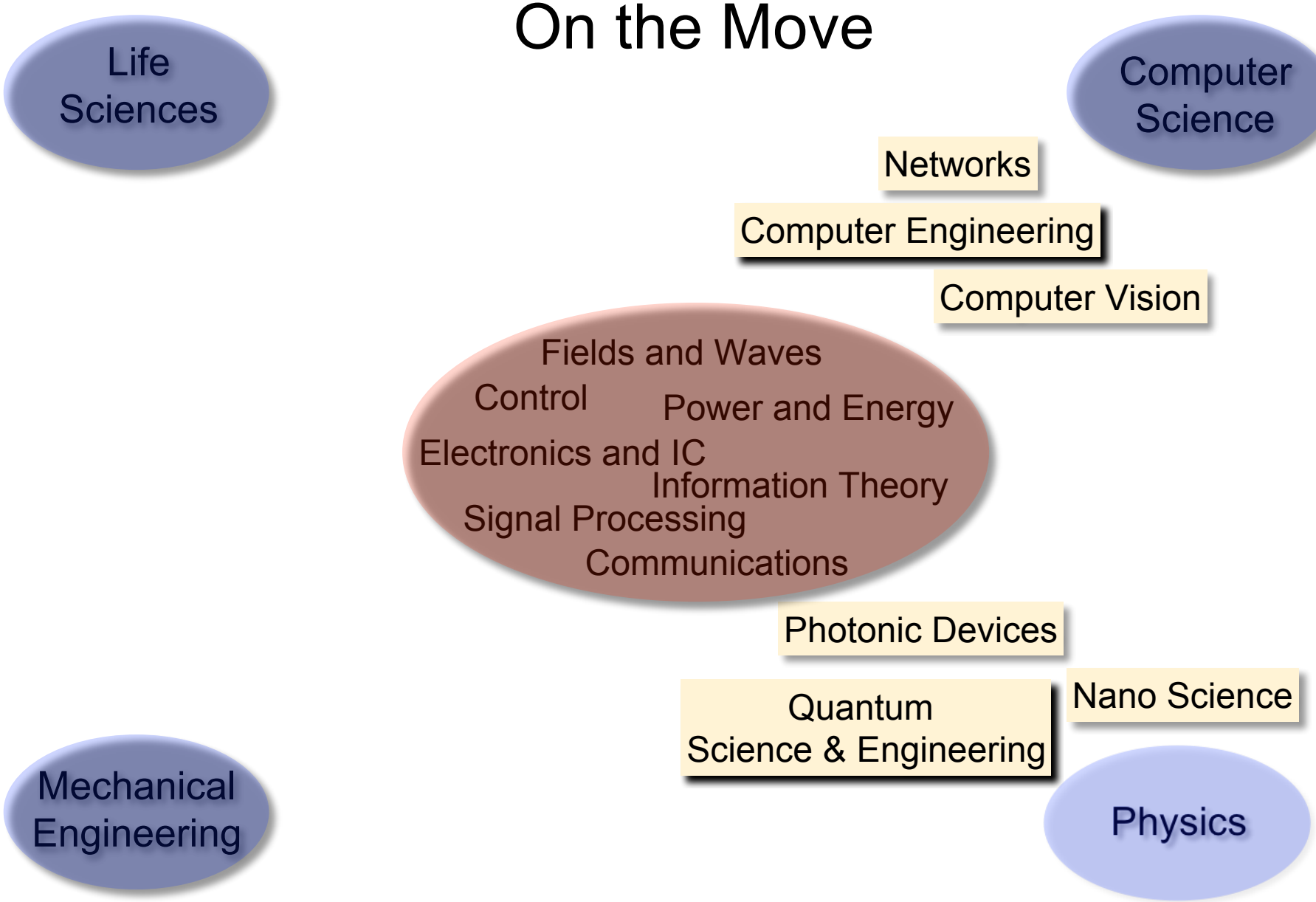
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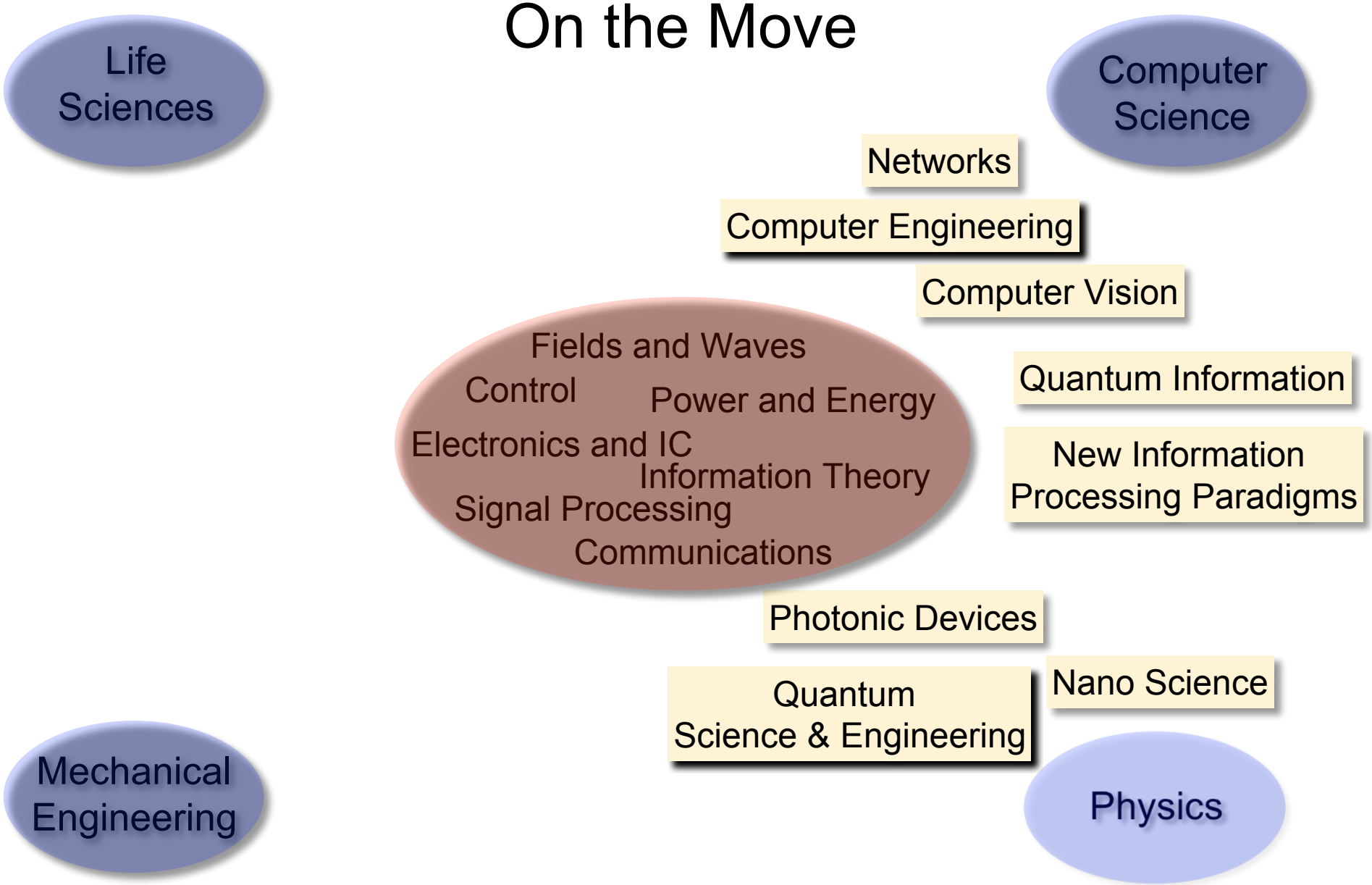
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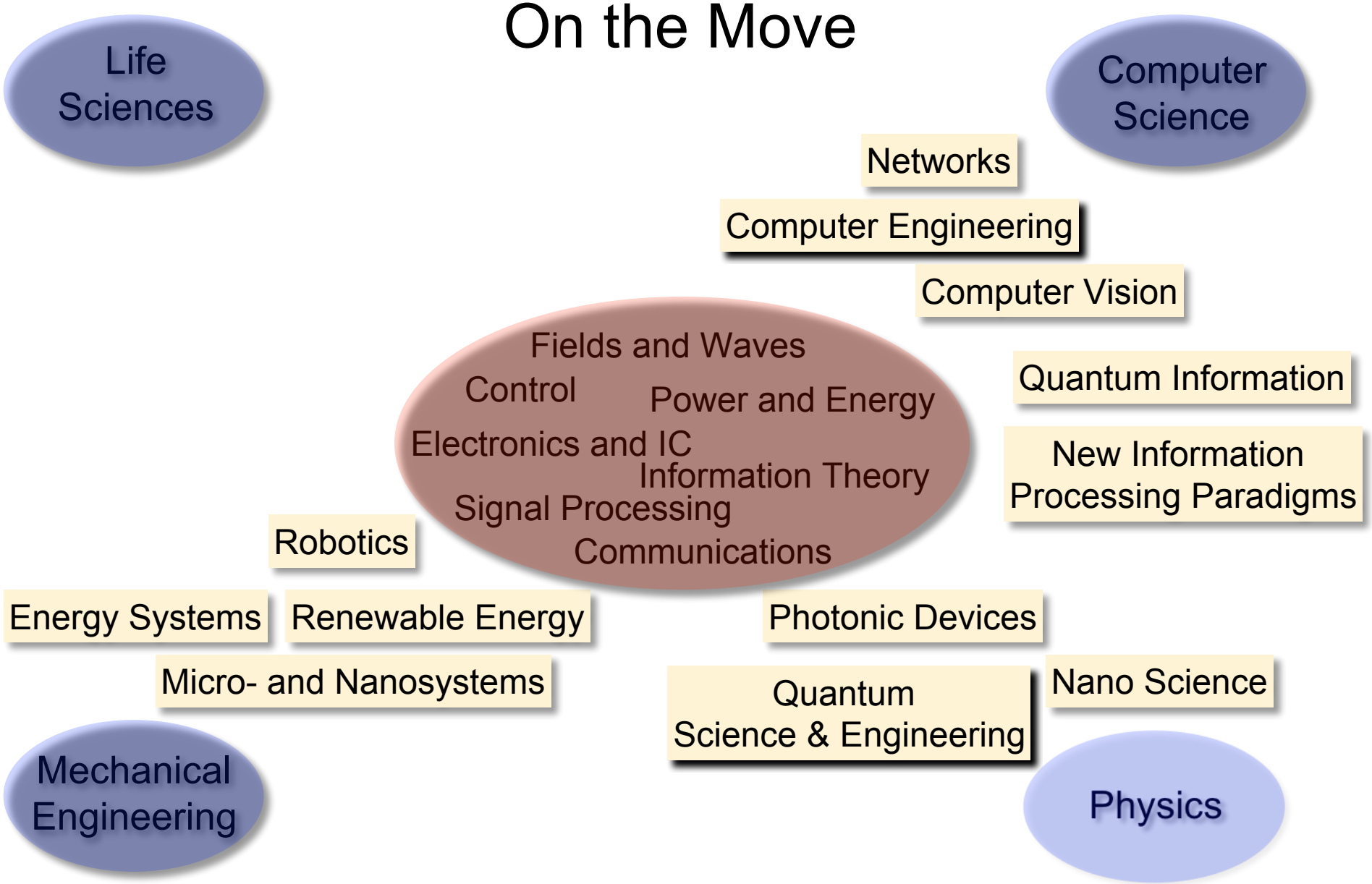
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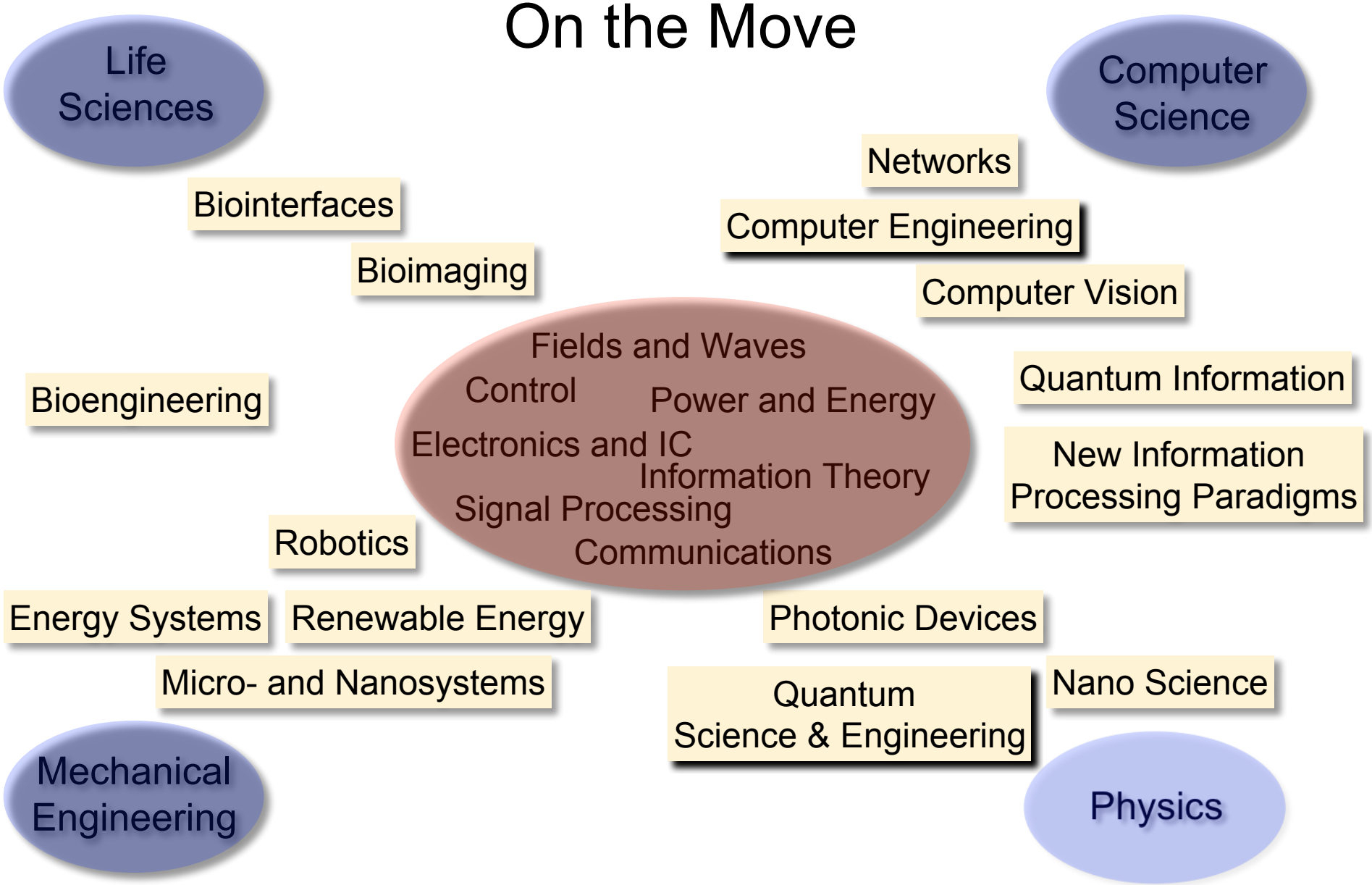
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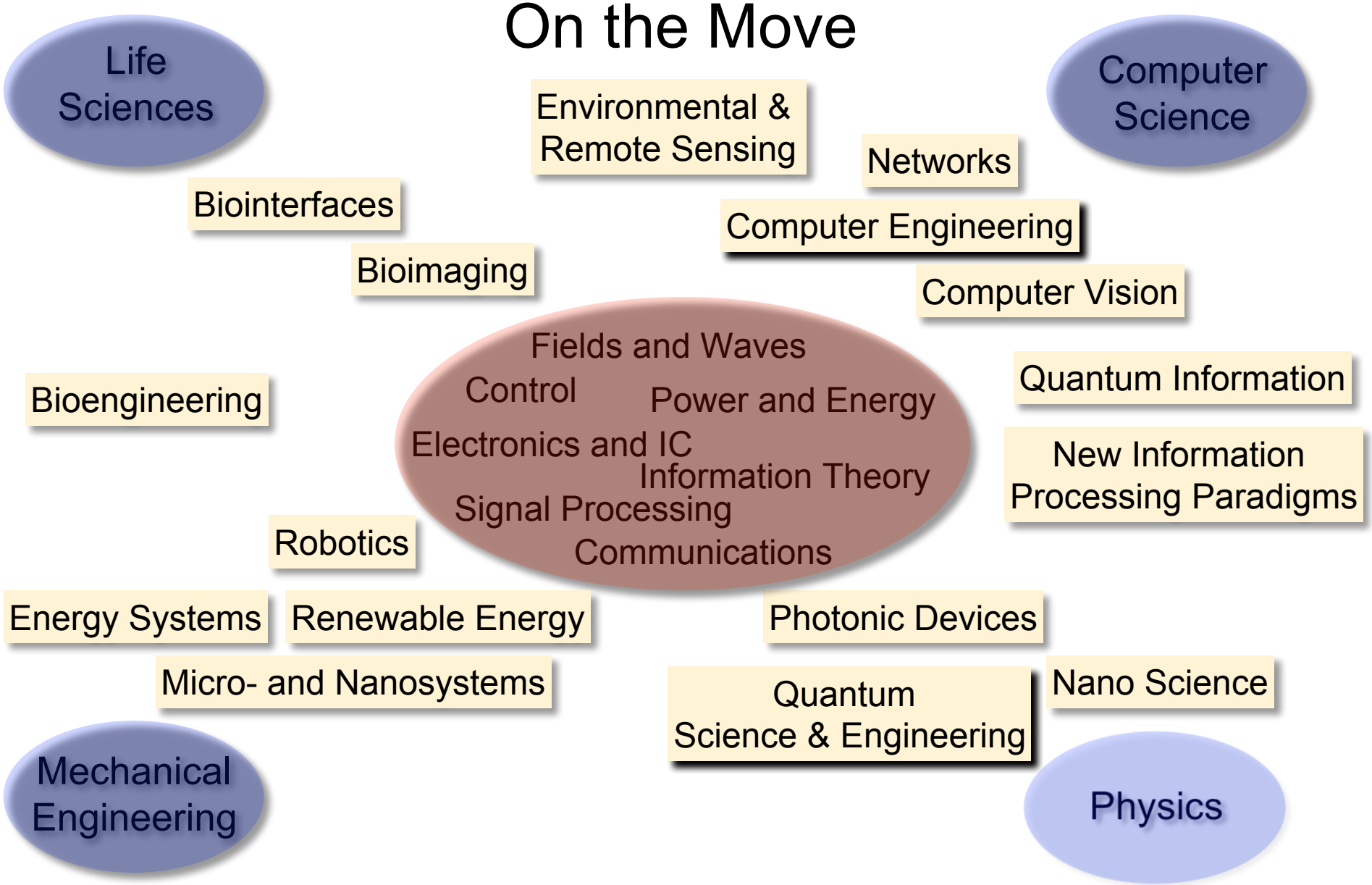
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Impact on Society and Industry

Excellent Students

Challenges

Overview

- Electrical Engineering
- ***Challenges***

  … what I would be interested in if I would still be young …
- Opinions

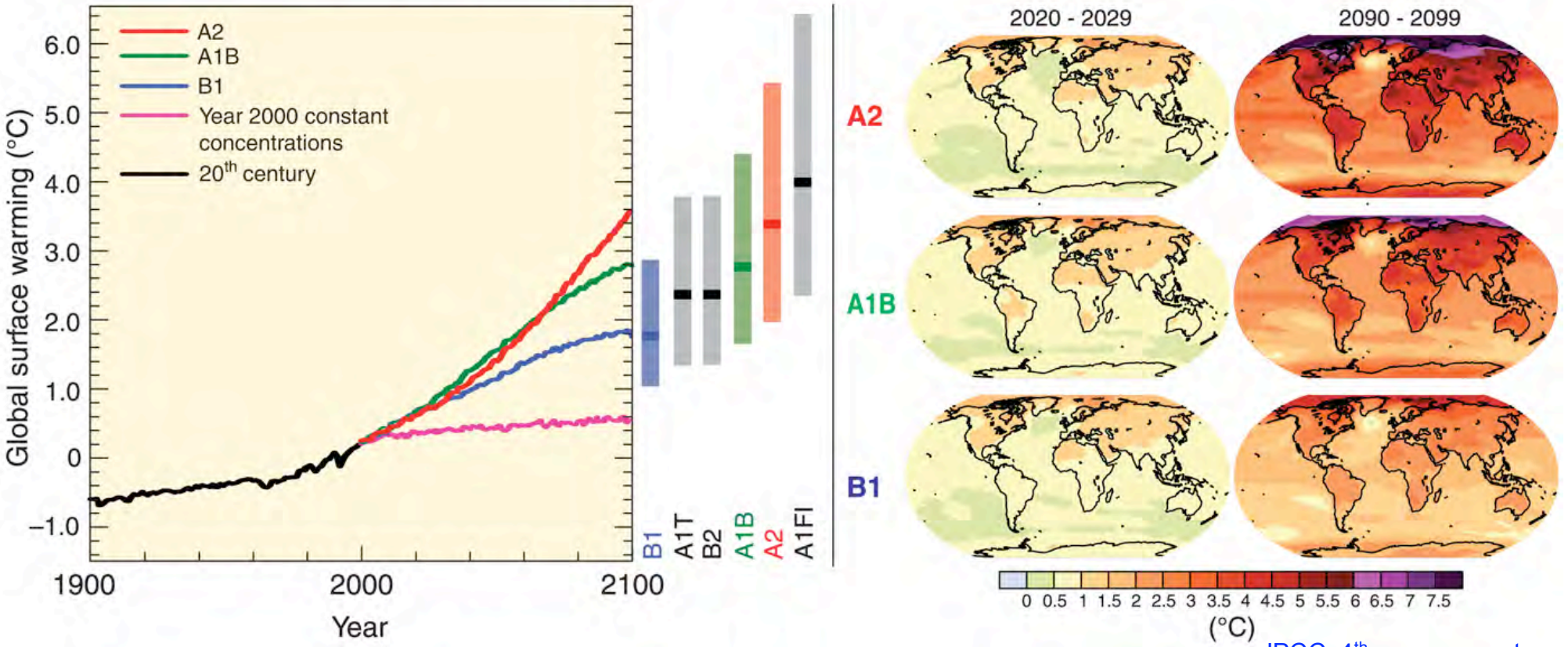
Environment

Energy

Challenge 1

Environment

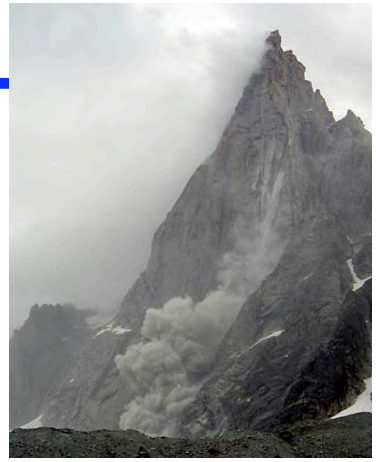
Atmosphere-Ocean General Circulation Model projections of surface warming

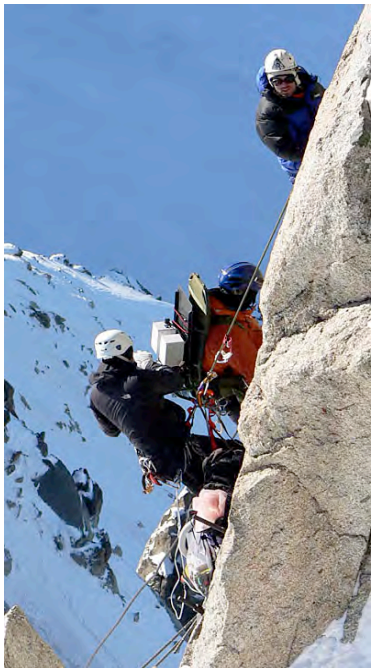


IPCC, 4th assessment report

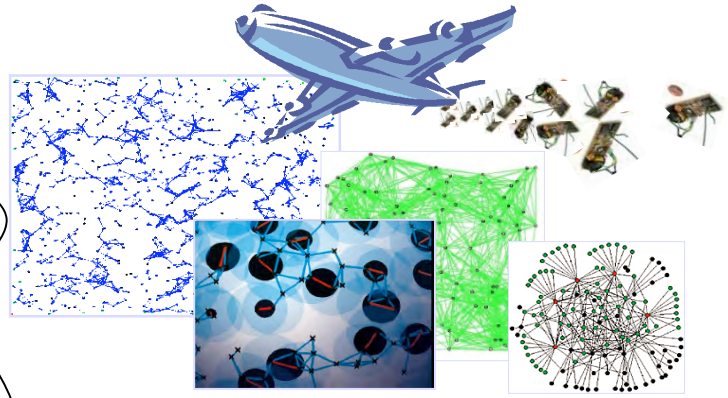
Example: Alpine Monitoring

- Provide ***long-term high-quality*** sensing in ***harsh environments***
- Obtain measurements that have ***previously been impossible*** (high resolution in time and space)

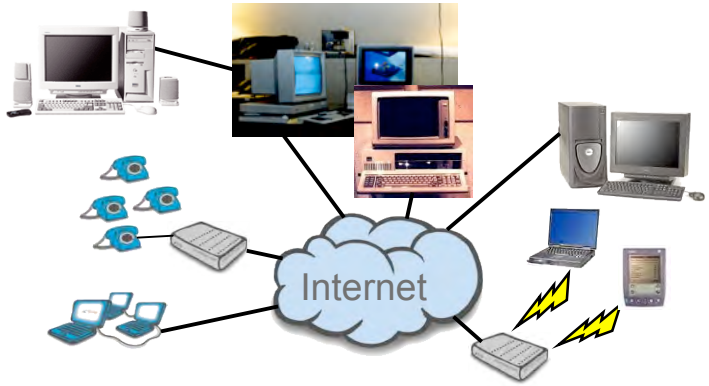


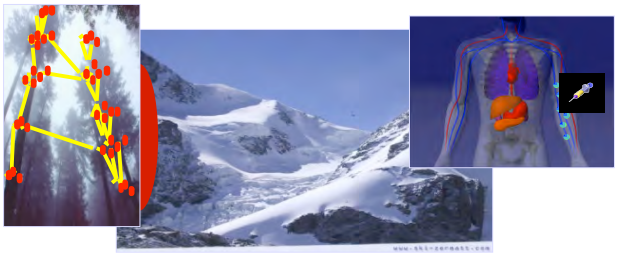


Reliability, delivery of information in ***near real-time***, and integration of ***diverse sensors*** are ingredients for the next generation of ***early-warning systems***.



Centralized Systems → **Networked Systems** → **Large-scale Distributed Systems**



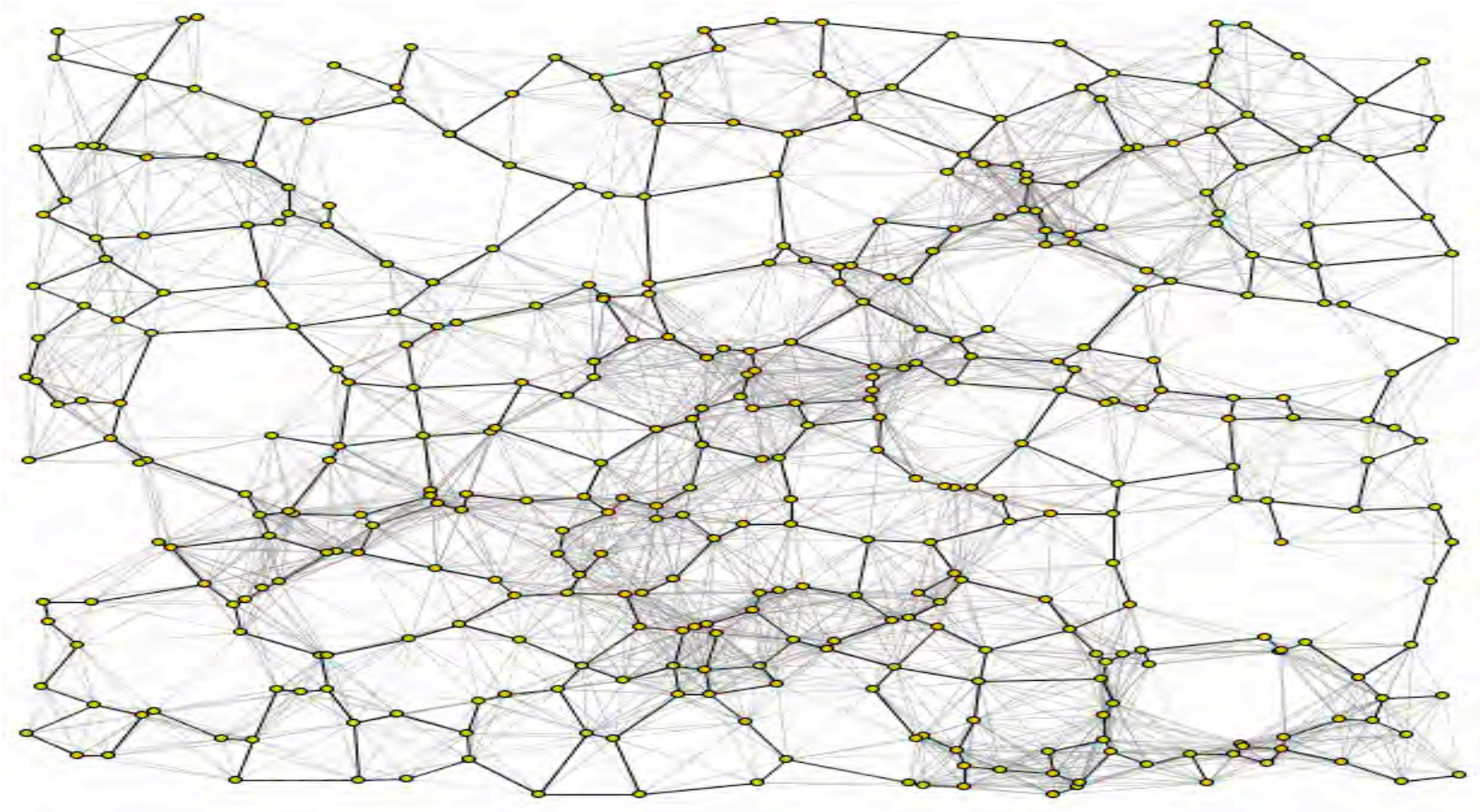


New Applications and System Paradigms

But where is EE ?

In Computer Science, the physical world has been (successfully) abstracted away from ‘computation’.

The Wireless Sensor Network Vision



But many systems for information and energy conversion, transmission and storage are closely integrated into their environment.

The Wireless Sensor Network Promises

- Sensor nodes are cheap, so we can have plenty of them.
- Nodes may be cheap, but deployment and maintenance is expensive.

- Additional redundant nodes make the system fault tolerant automatically.
- More nodes make the system more fragile.

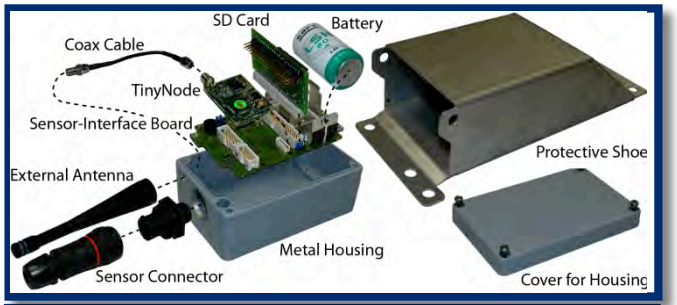
Role of EE – Scientific Challenges

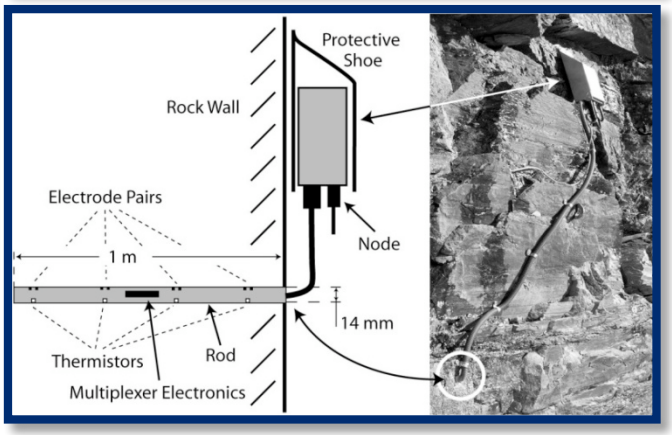
- ***Physical interaction with the environment***
  - Energy (saving, harvesting)
  - Automatic control
  - Communication (limits)
  - Sensors and actuators

- ***Make large-scale distributed systems viable***.

- ***Interaction with natural sciences***
  - New models and methods (information processing)

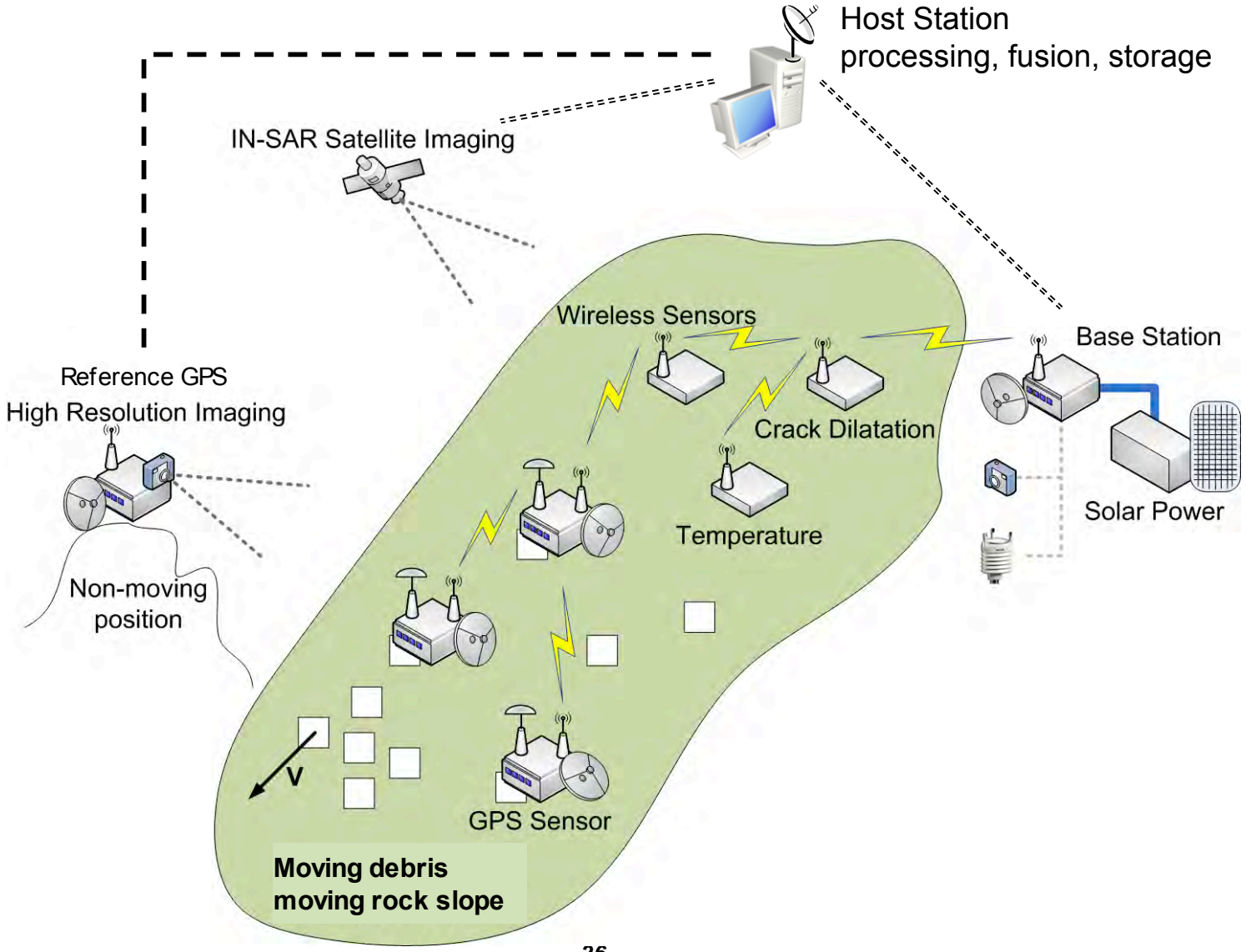
Interaction with Environment





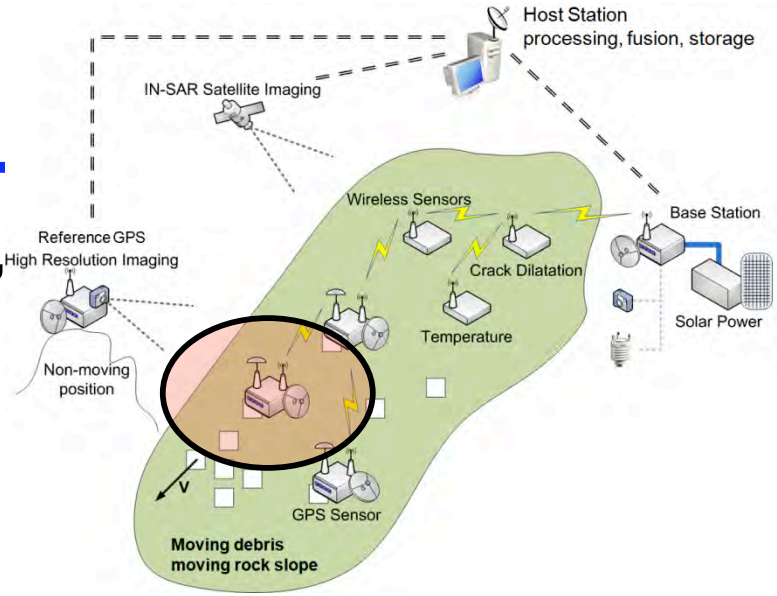
various sensor modalities
WSN, base sation
host, database

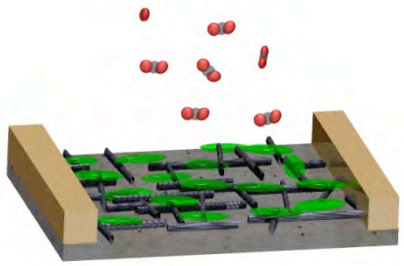
Typical Platform



Challenges

- ***Sensors and interfaces*** (air pollution, sensitivity, calibration, low energy, low cost, integration, …)





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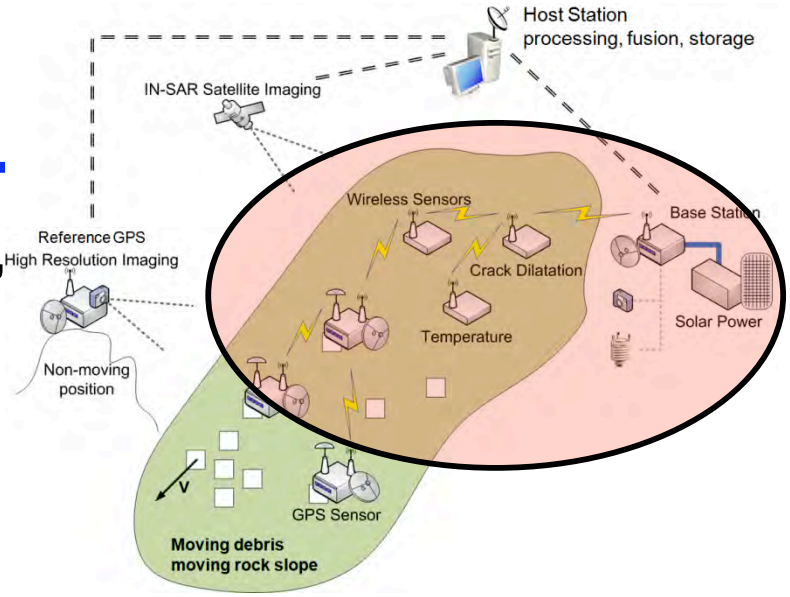

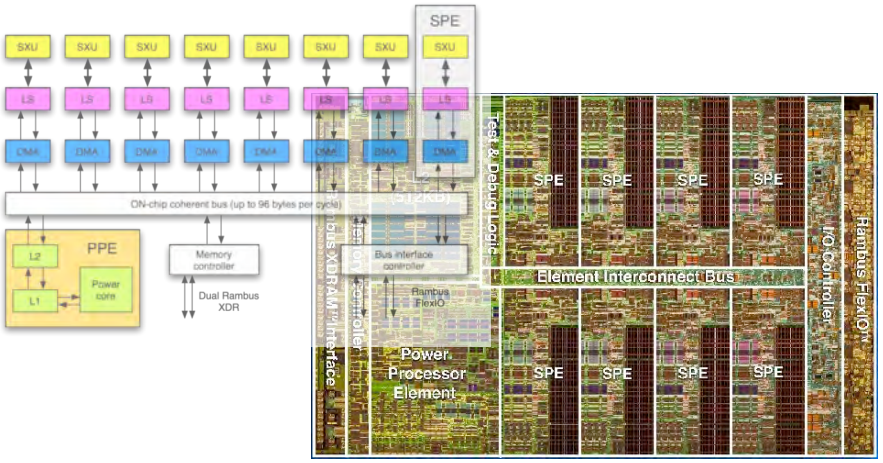

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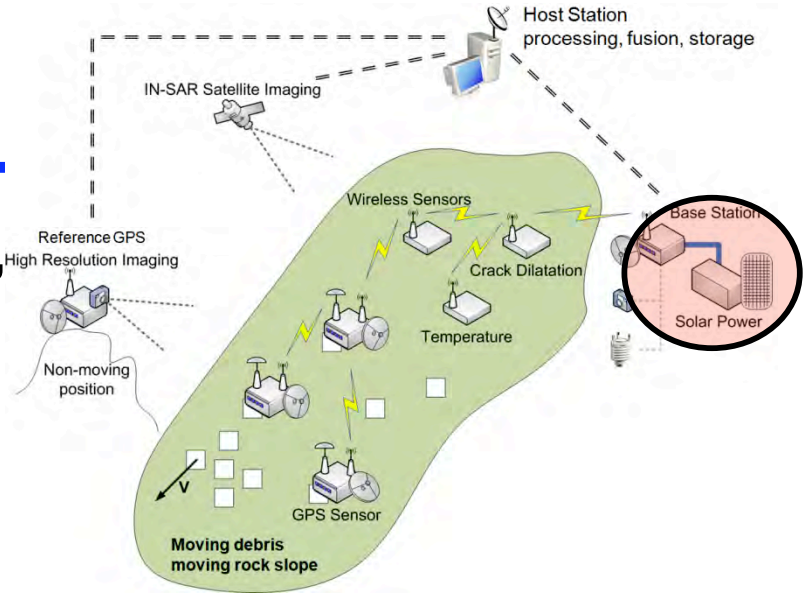

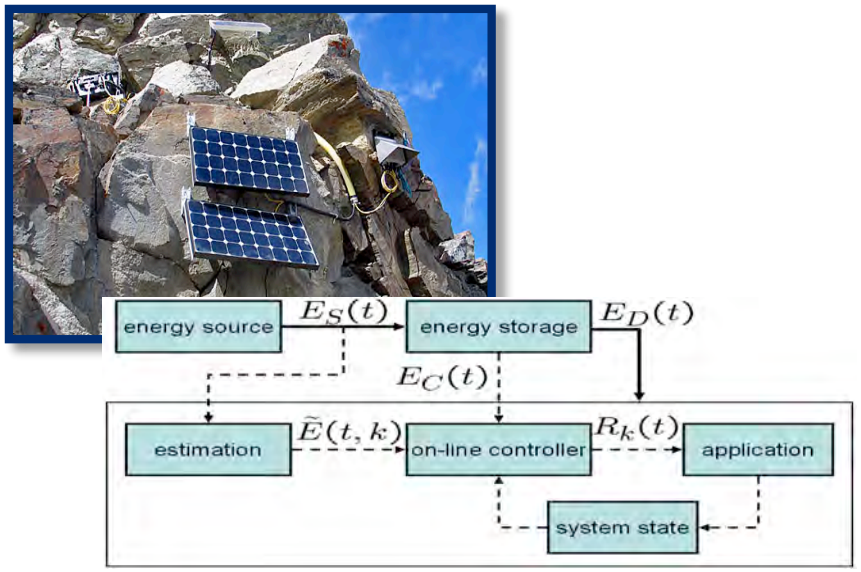

Challenges

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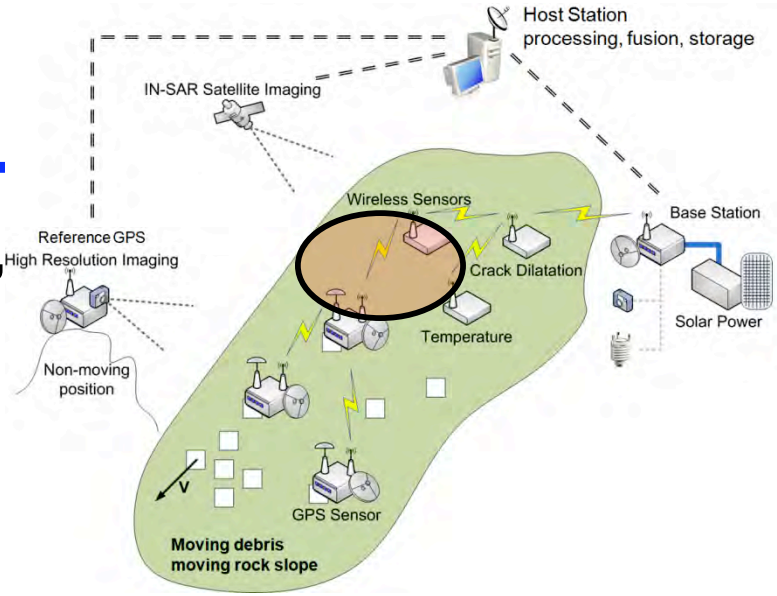
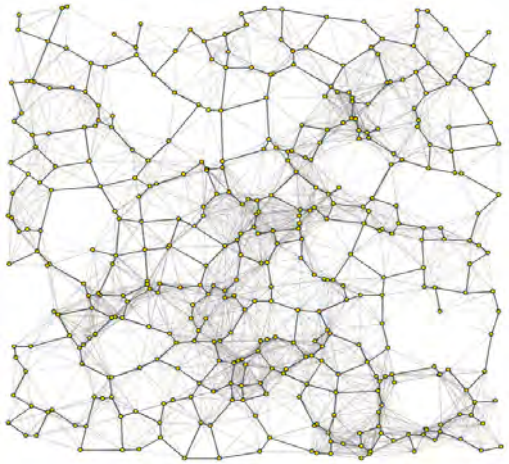
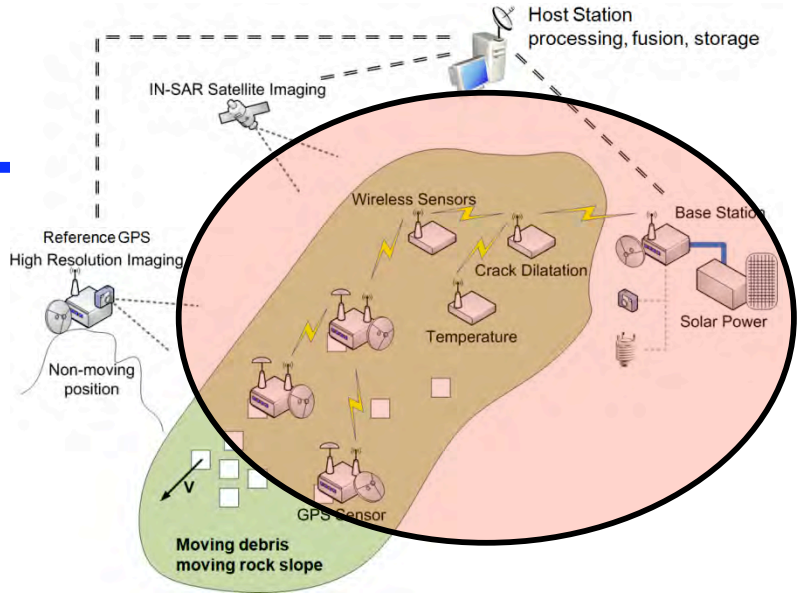
- **Low energy operation** (technology integration, parallel processing, power management, …)
- ***Energy harvesting*** (application control, …)
- ***(Wireless) networking*** (capacity, ad-hoc networking, low power, new communication principles, mobility, …)

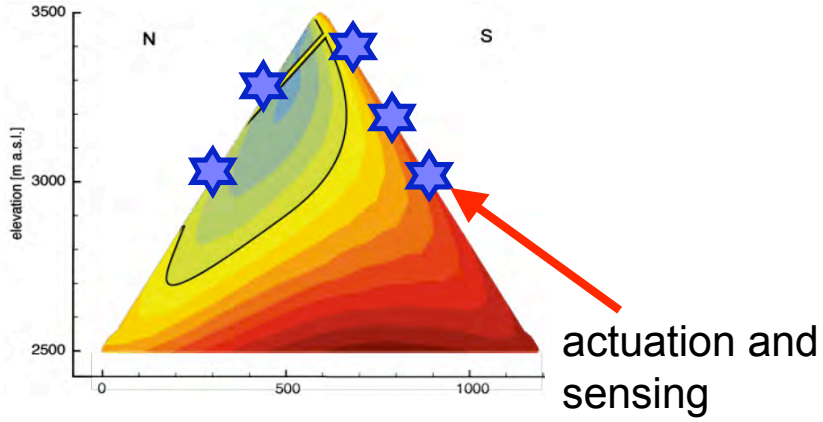




Challenges

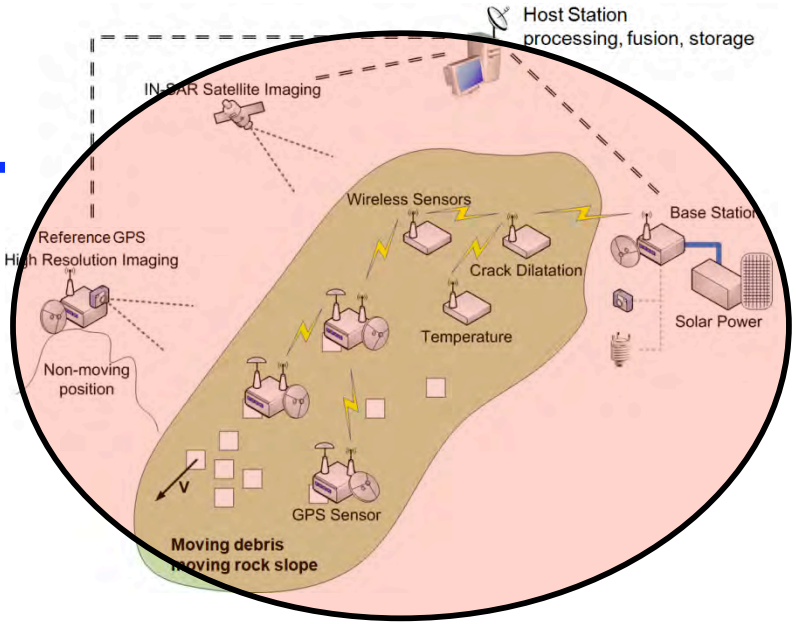
- ***Distributed control*** (sensor-actuator coupling, energy balancing, …)

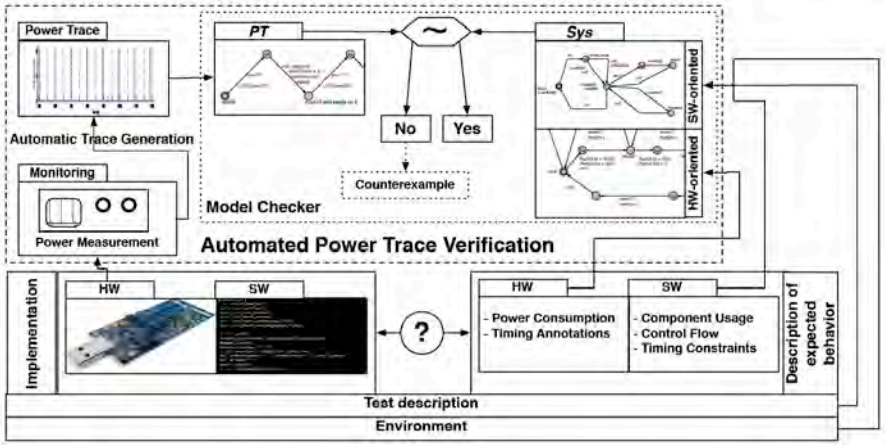




Challenges

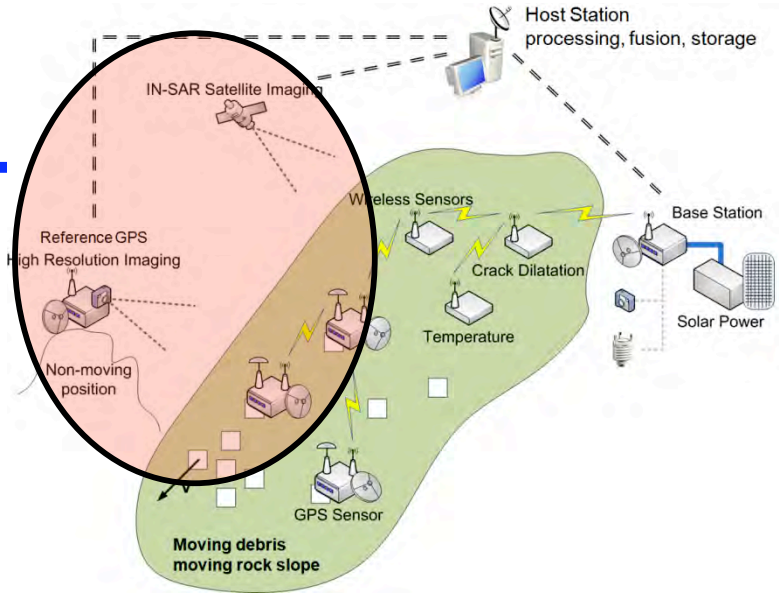
- ***Distributed control*** (sensor-actuator coupling, energy balancing, …)
- ***Predictability and reliability*** (formal verification, (energy) testing, observability…)

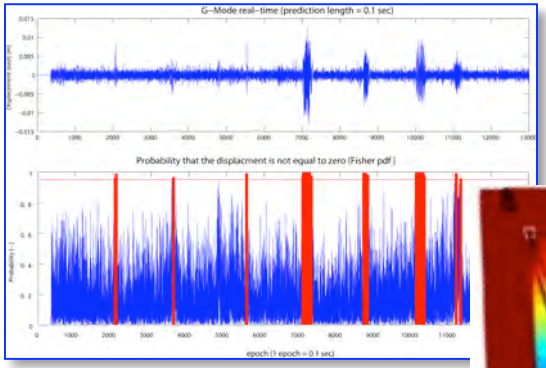


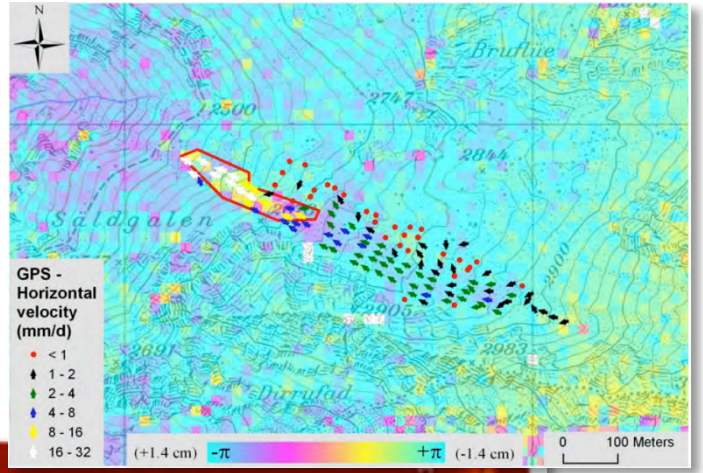


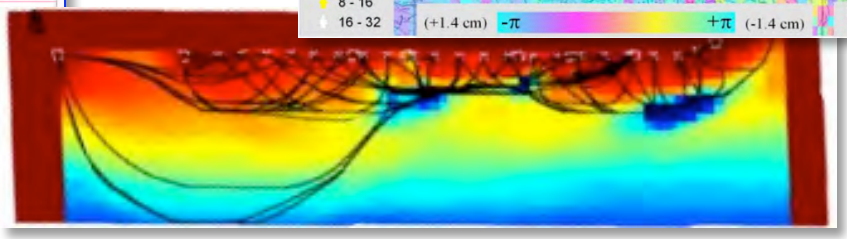
Challenges

- ***Distributed control*** (sensor-actuator coupling, energy balancing, …)
- ***Predictability and reliability*** (formal verification, (energy) testing, oberservability…)
- ***Modeling*** (new models and methods for data analysis, sensing at diverse spatial and temporal scales, data fusion)









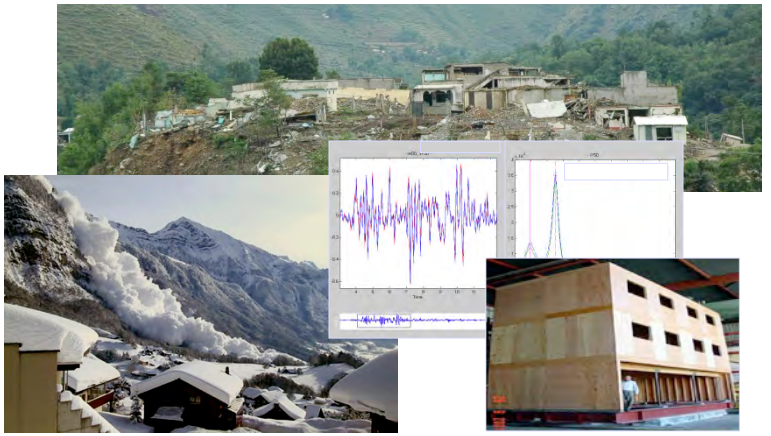
Application Visions

Forest Fires

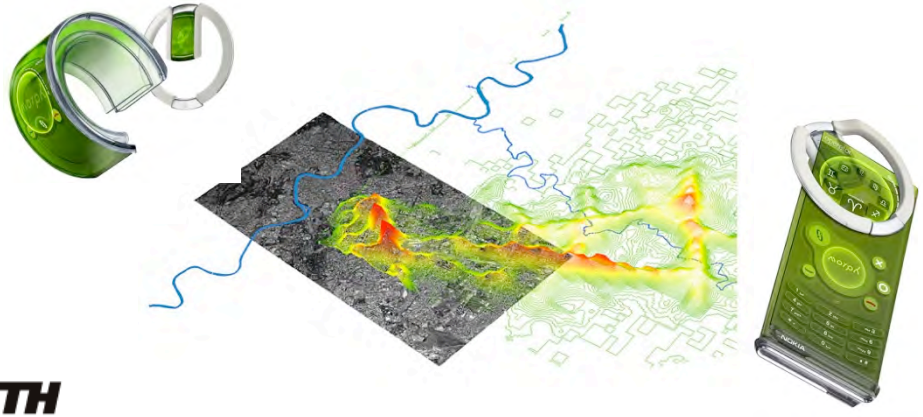
Maintenance

Factory Automation

Natural Hazards

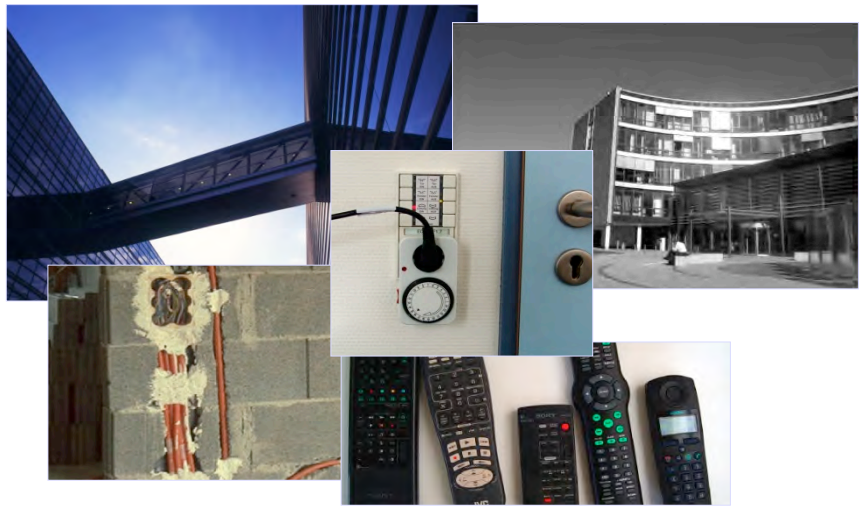


Community Sensing

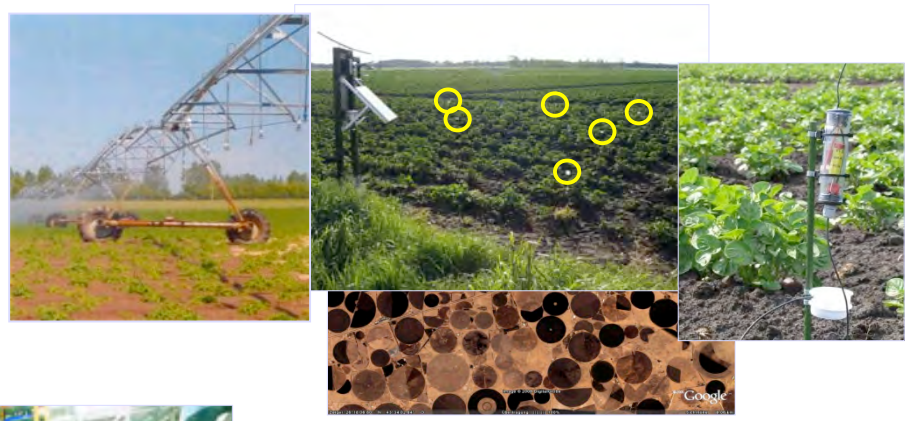


Application Visions

Building Automation



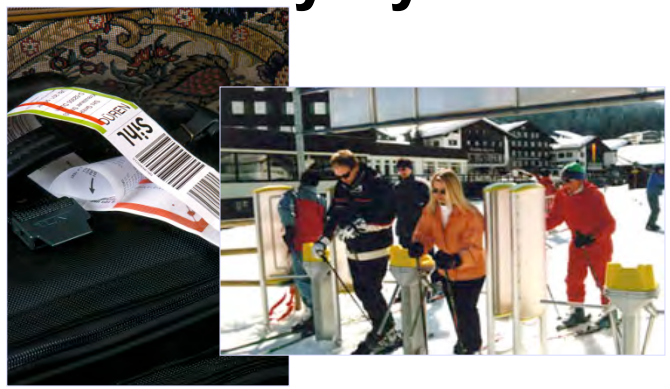
Precision Agriculture



Health Care

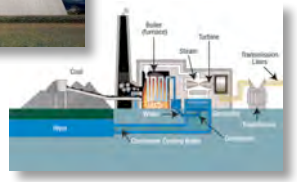
Logistics

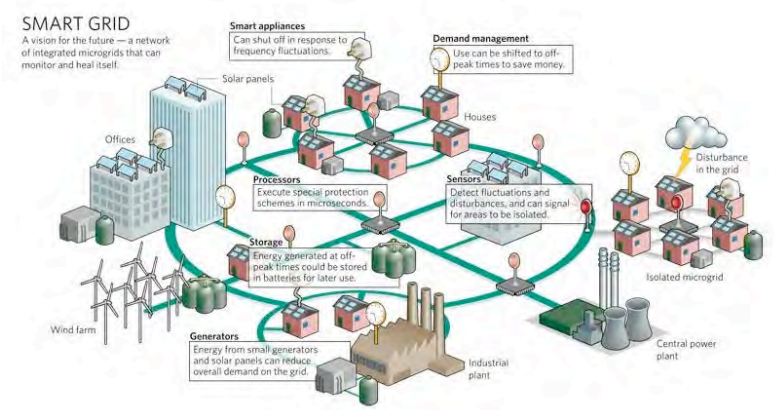
Security Systems



Challenge 2

Energy





Centralized Systems

Networked Systems

Large-scale Distributed Systems

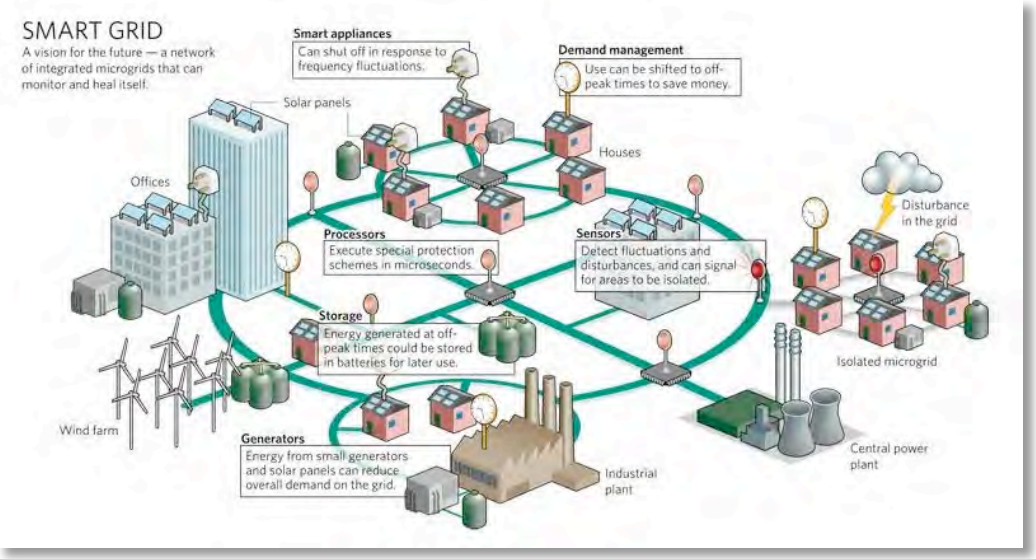
New Applications and System Paradigms

In many US universities, the power engineering faculty numbers have reduced to a single person.

Vijay Vittal

Challenges

- Large scale distributed energy and information networks
- Energy router
- Distributed sensing, actuating, monitoring and control for stability
- Large scale HVDC networks
- Energy storage on various temporal and spatial scale
- Customer privacy in a two-way communication system



It will be hard to (re) establish …

- Starting ***fight for ownership*** of “energy”
- Lack of available ***qualified people***
- ***Missing respect***:

engineering	vs.	science	??
slow	vs.	fast innovation cycles	??
norms/standards	vs.	playground	??
dependability	vs.	unreliability	??

Overview

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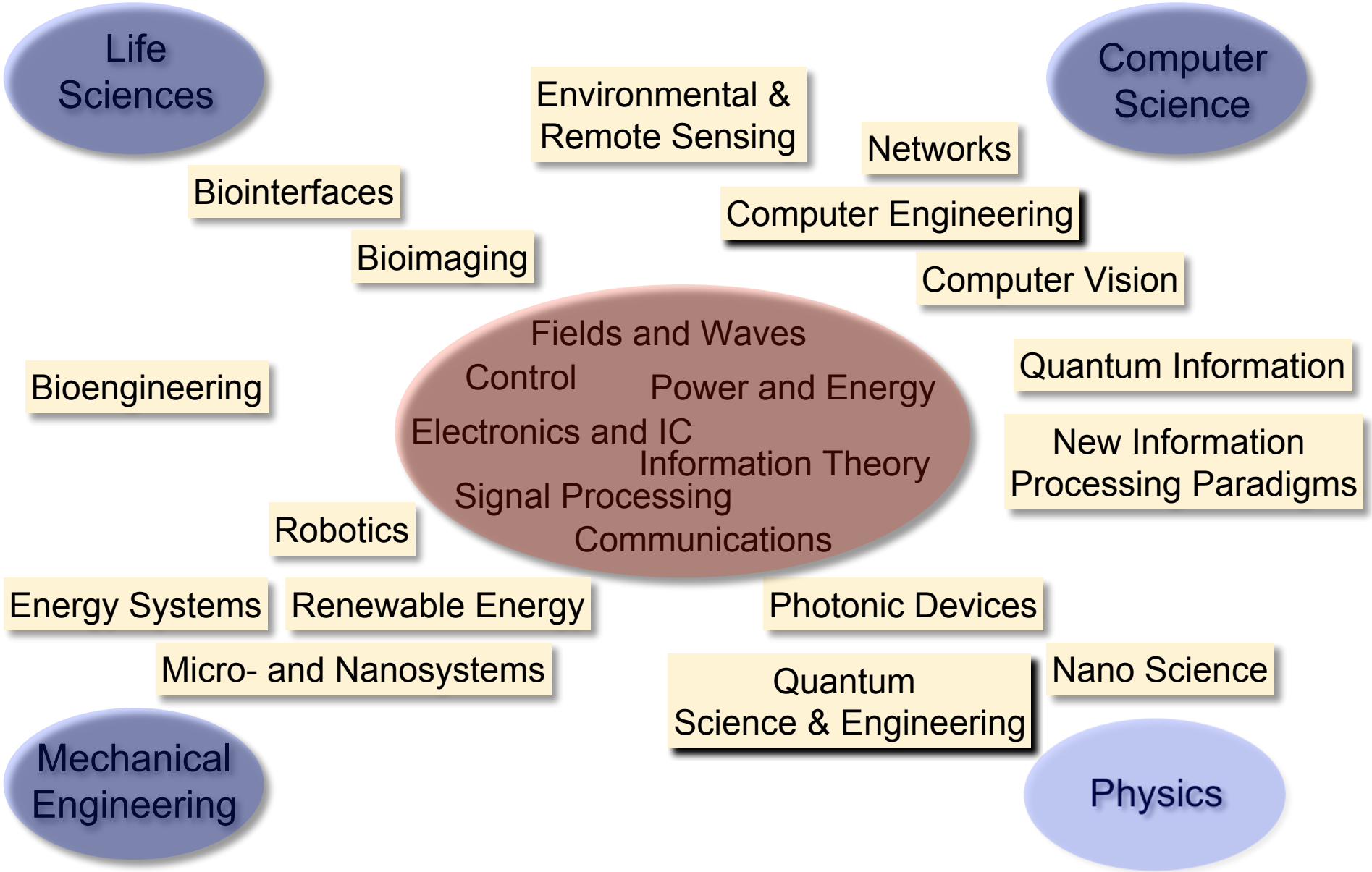
- Challenges
- ***Opinions***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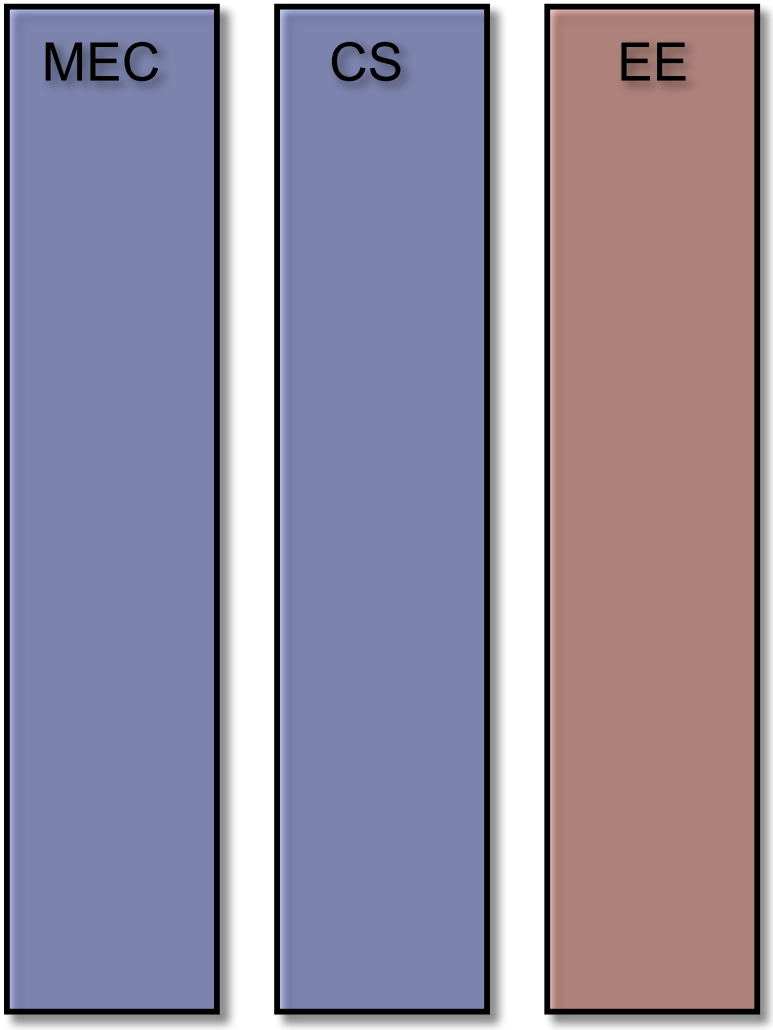
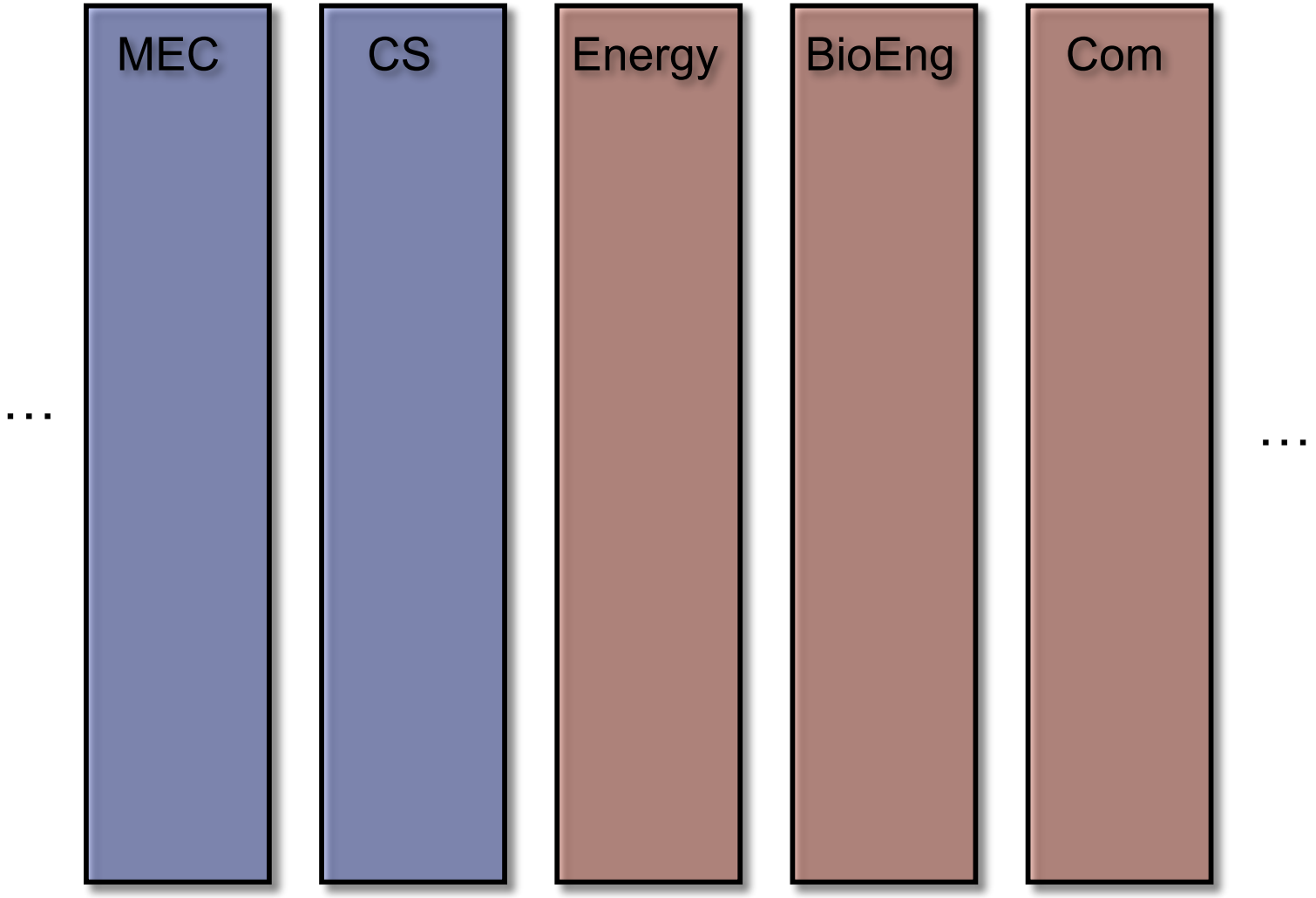
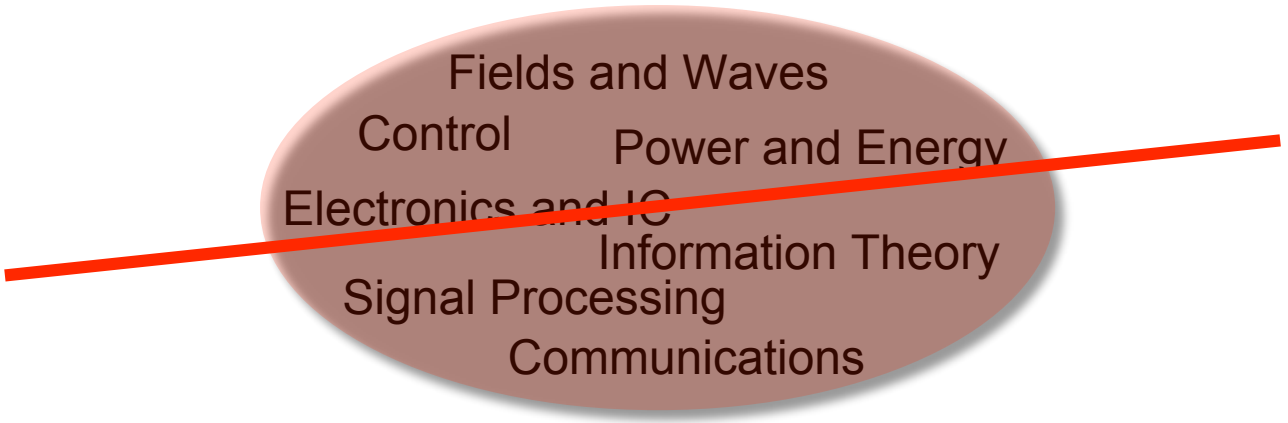
Strategies

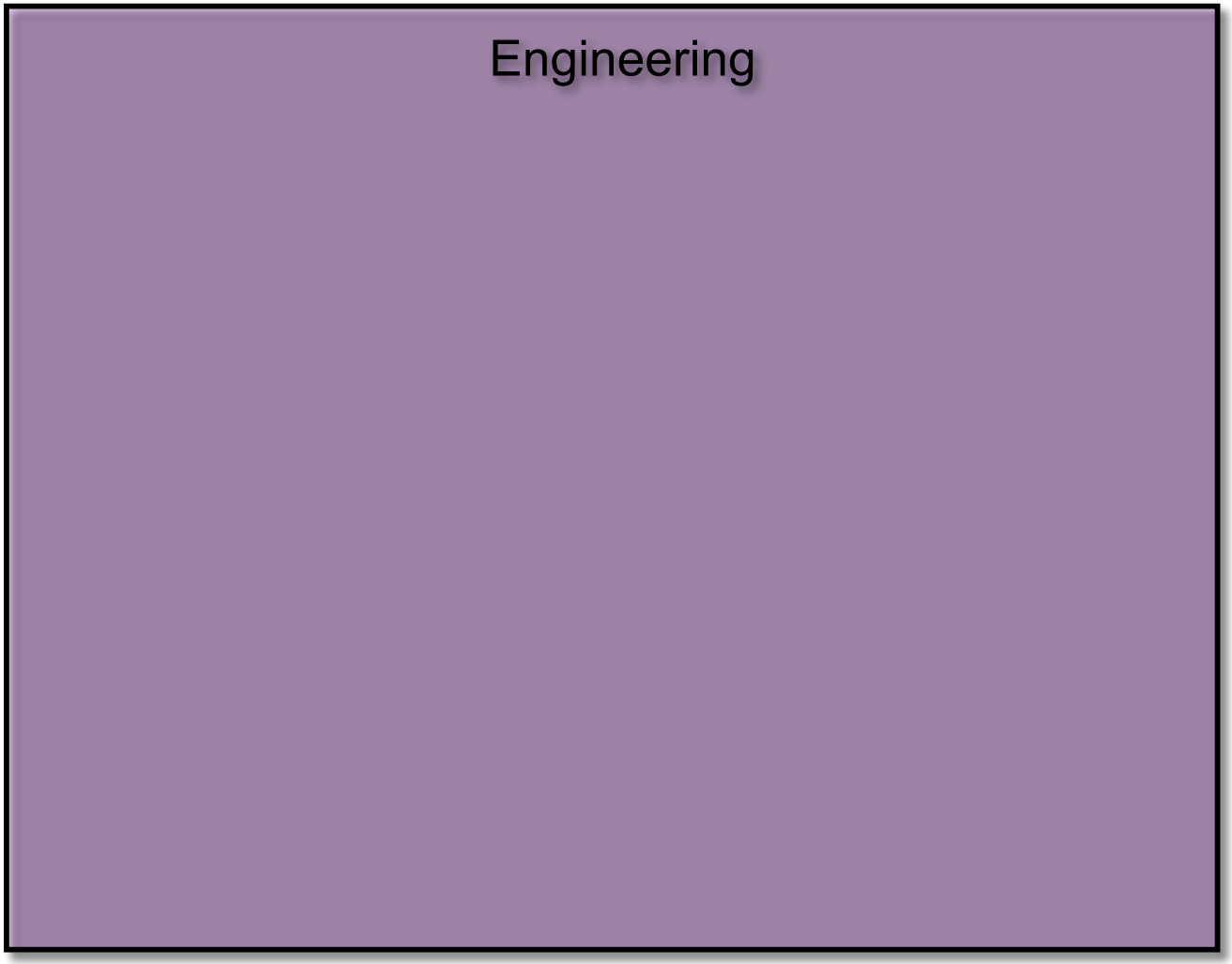


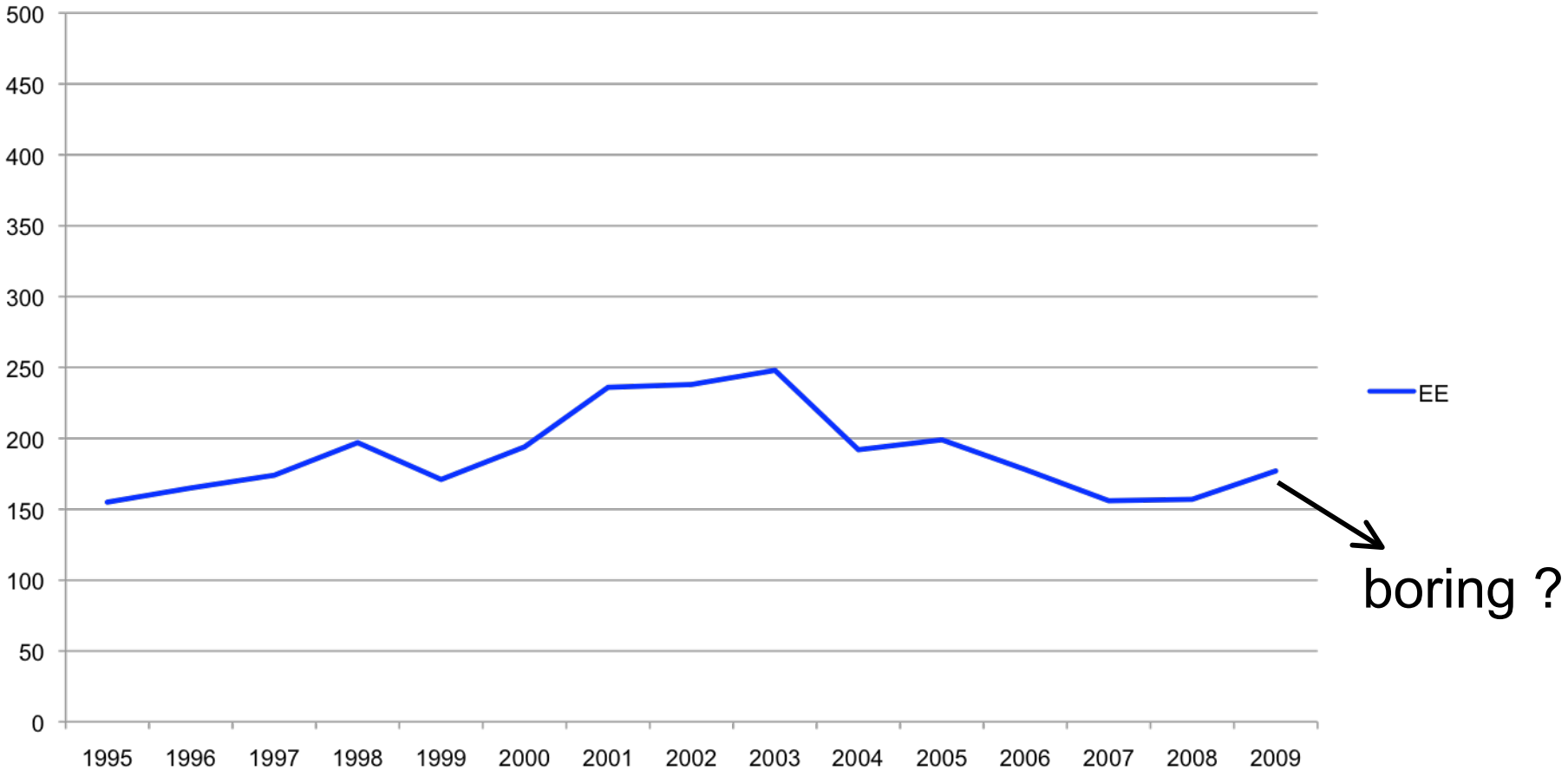
Divide and Compete



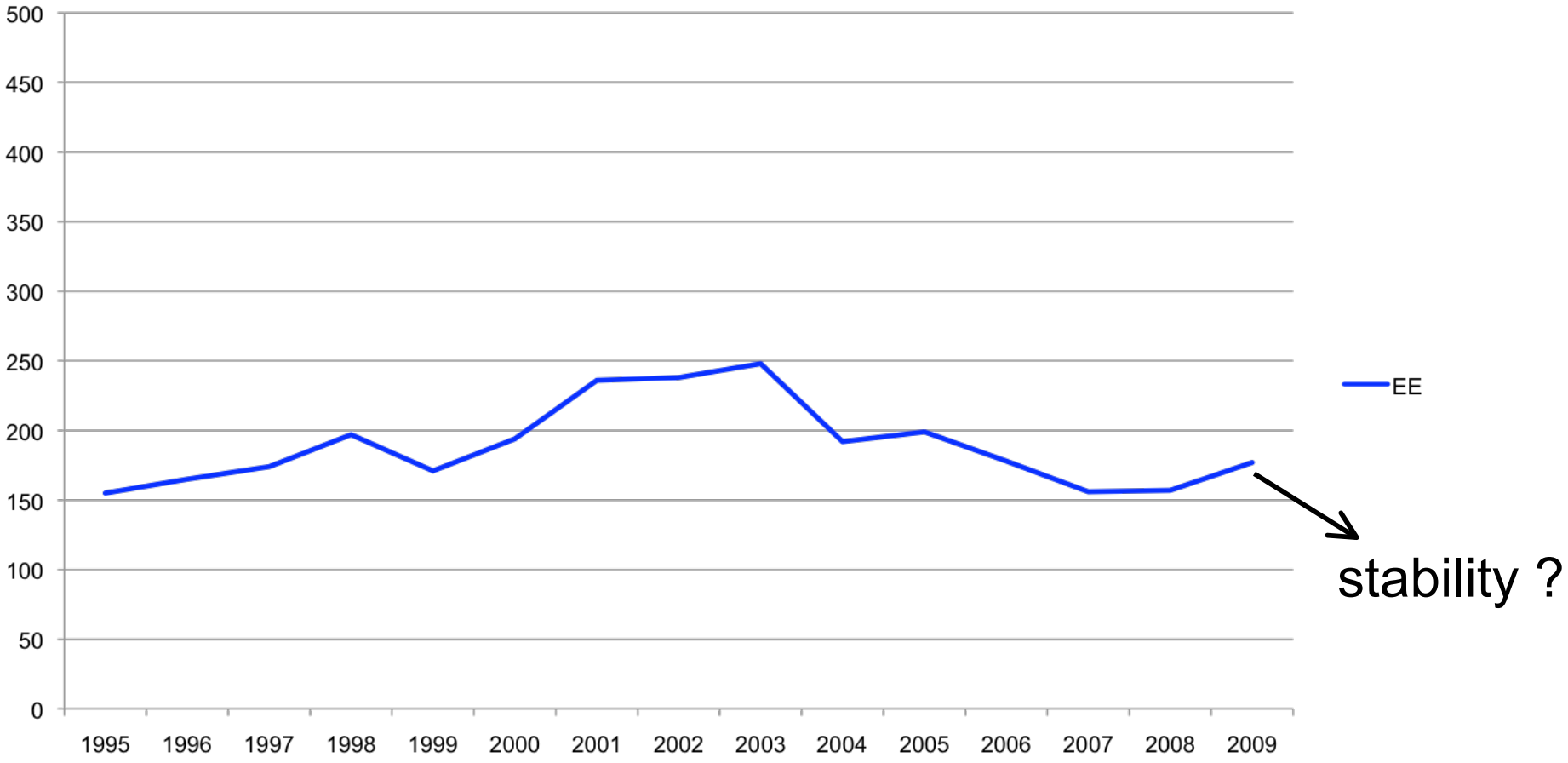

Fields and Waves
Control
Power and Energy
Electronics and IC
Information Theory
Signal Processing
Communications

Dissolve

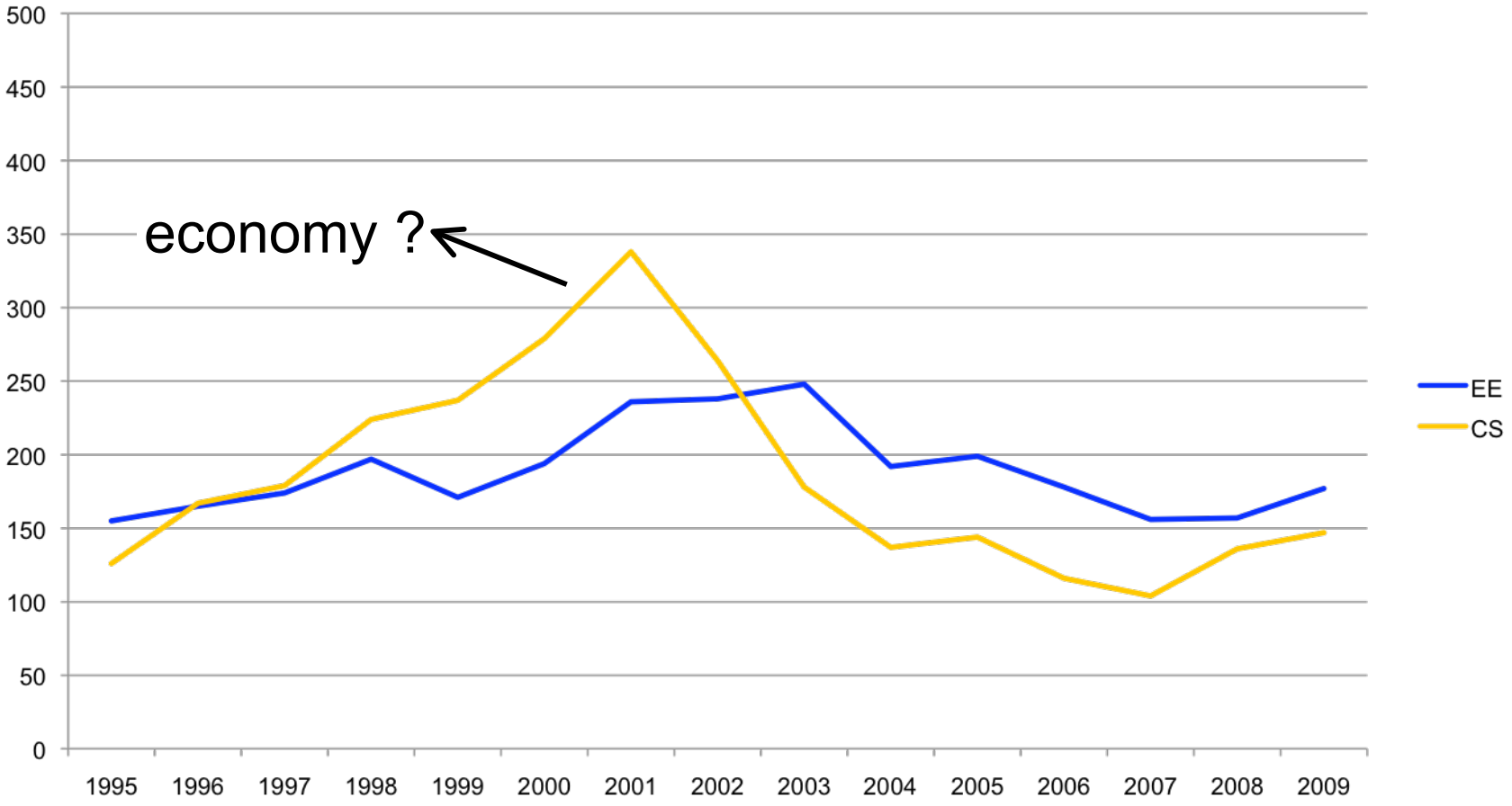




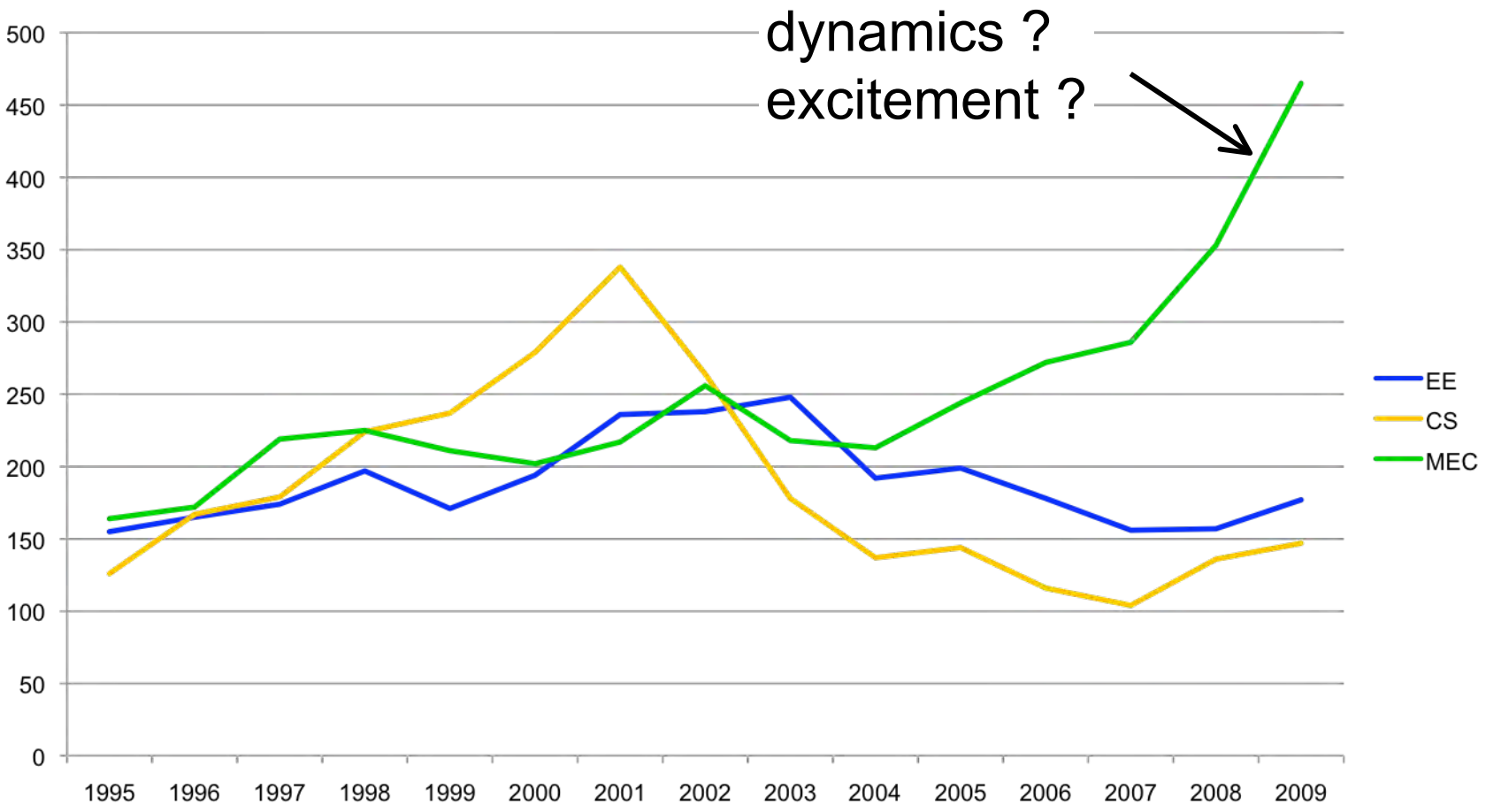
ETHZ – number of starting bachelor students



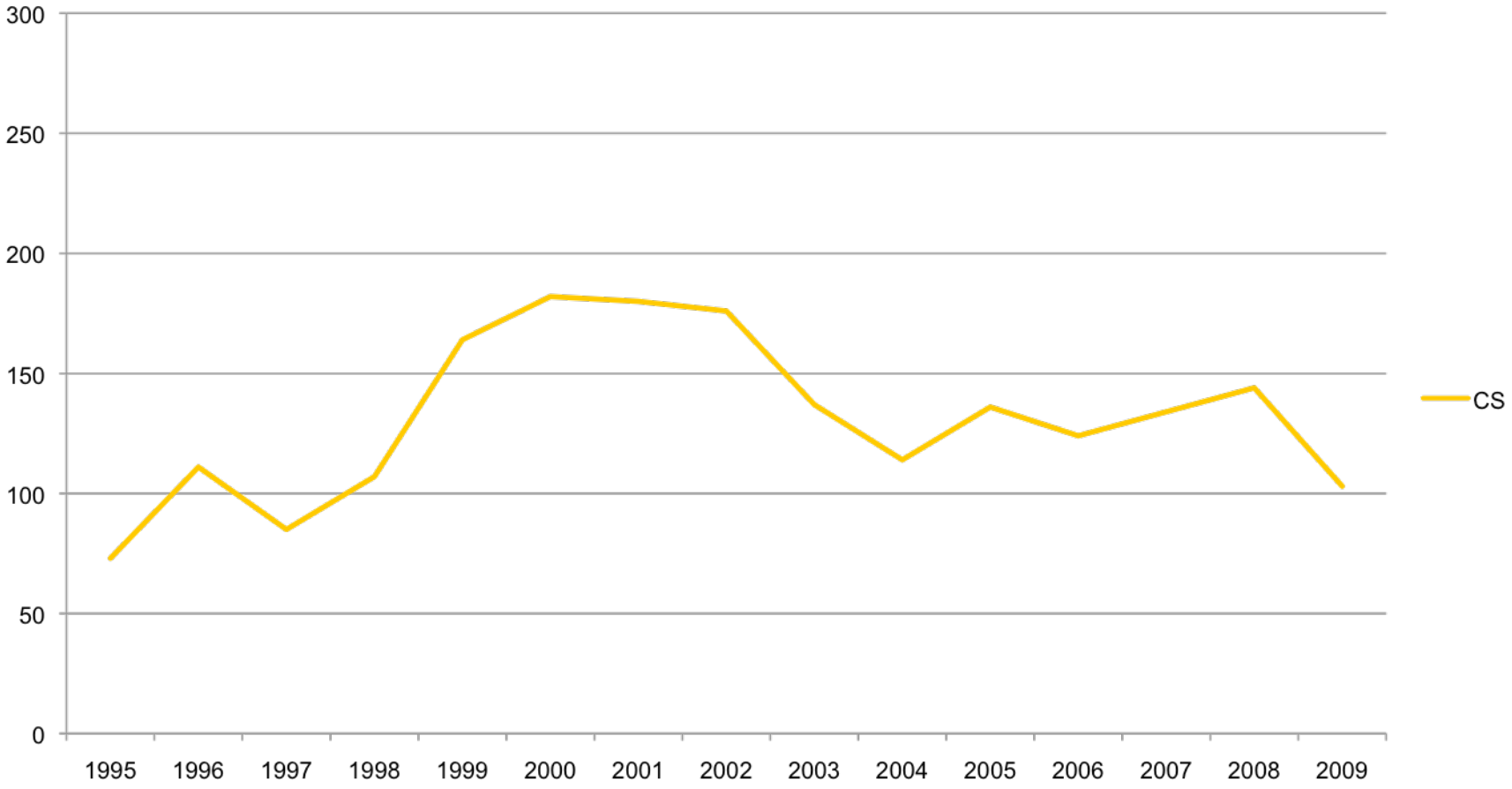
ETHZ – number of starting bachelor students



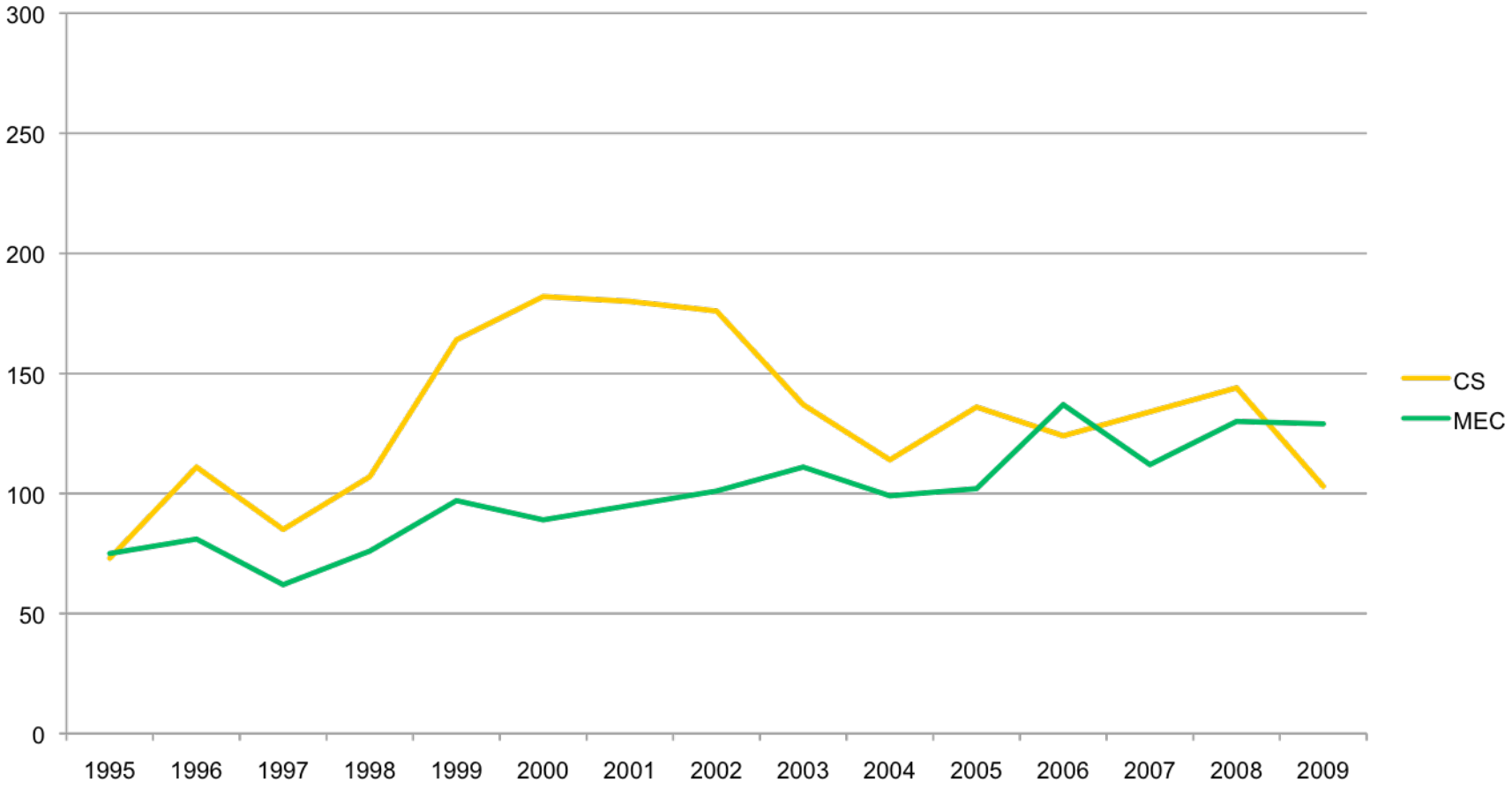
ETHZ – number of starting bachelor students



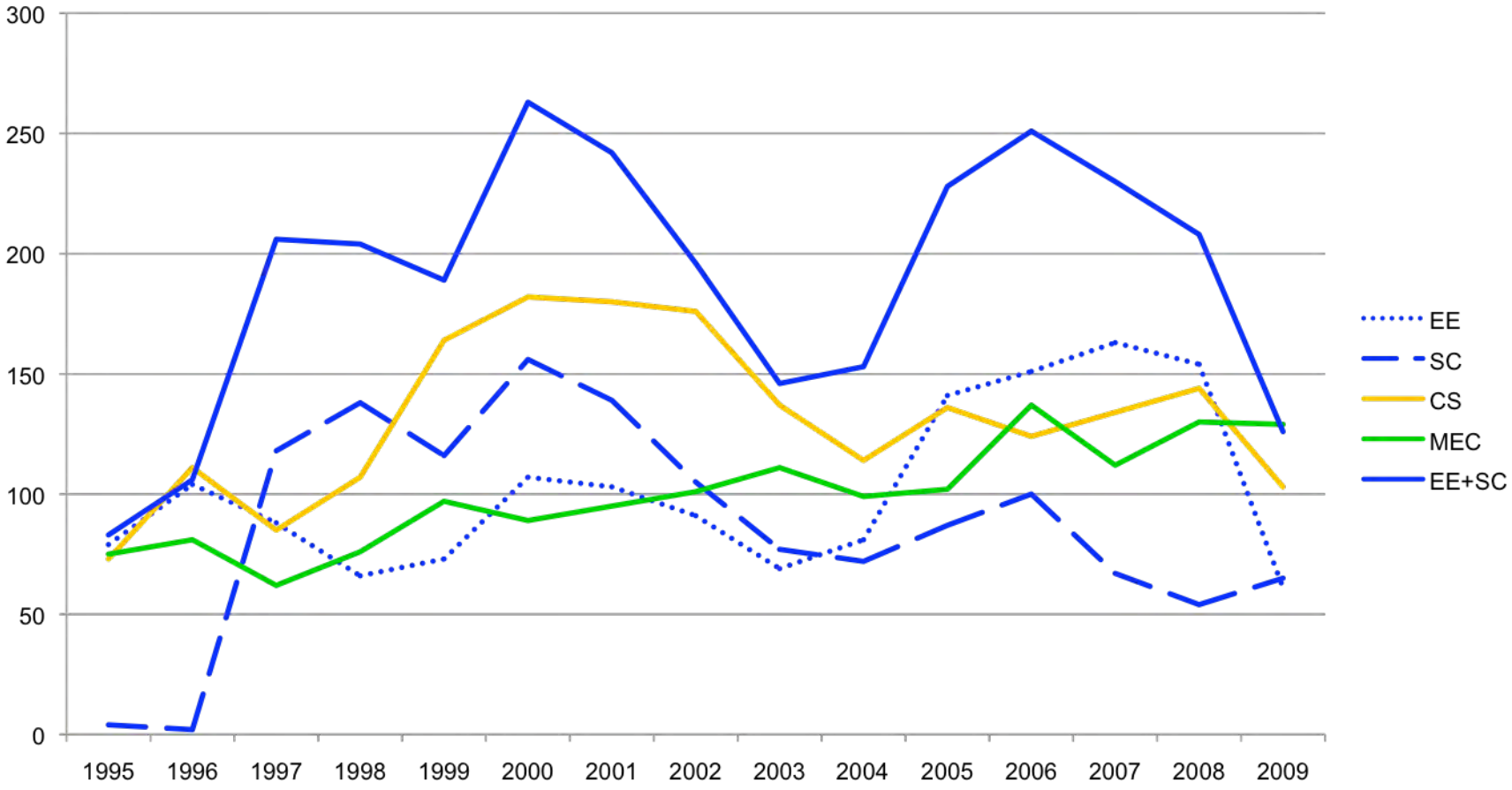
ETHZ – number of starting bachelor students



EPFL – number of starting bachelor students

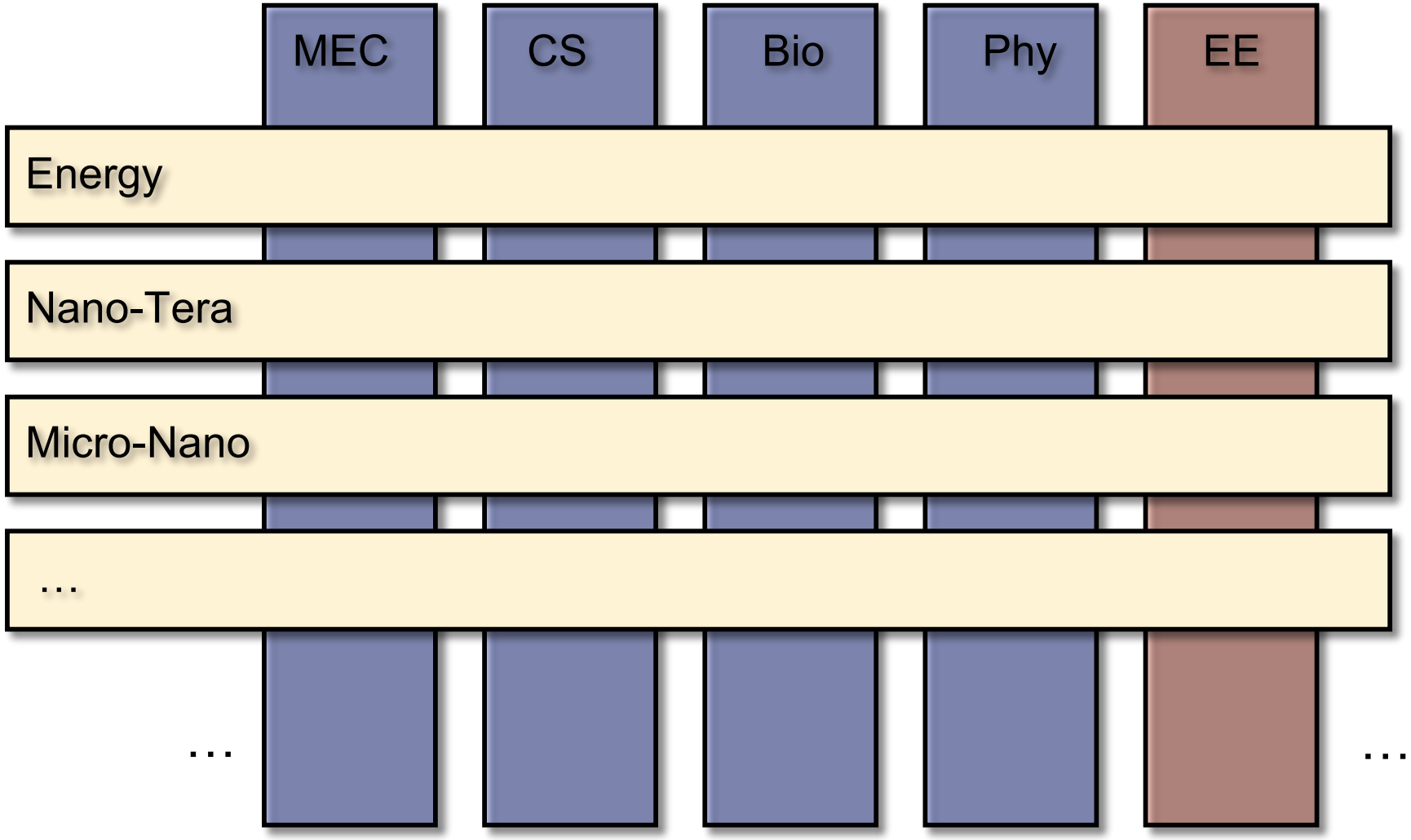


EPFL – number of starting bachelor students



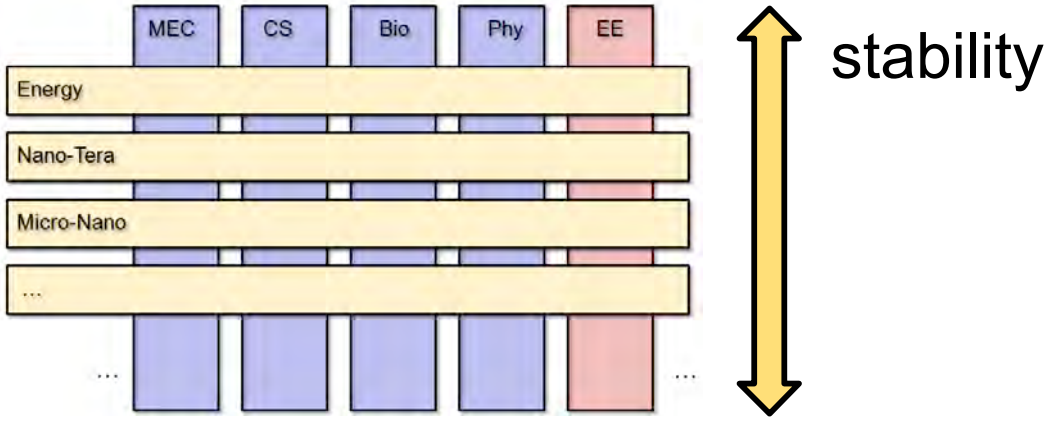
EPFL – number of starting bachelor students

Matrix



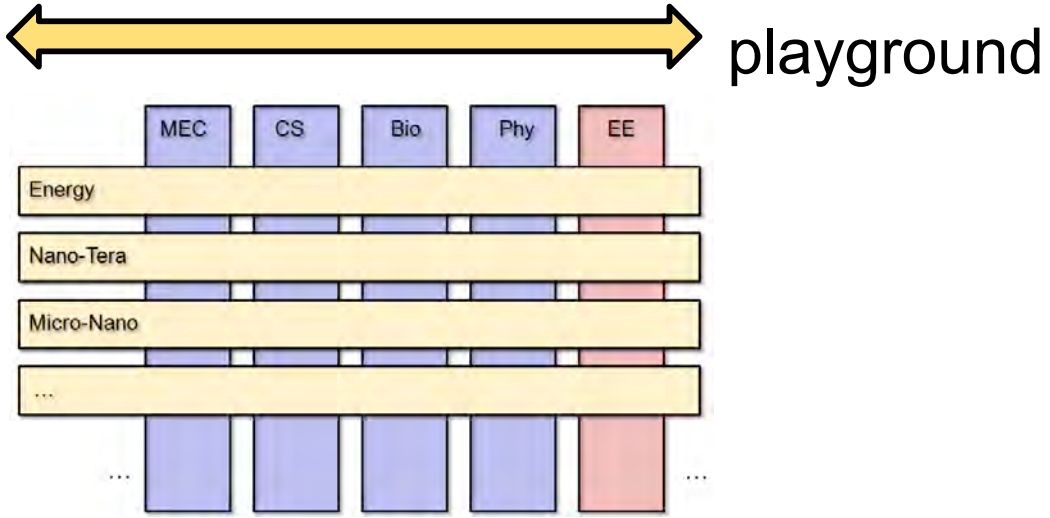
Maintain and re-establish the core of EE

- EE has a lot to offer and has a specific viewpoint on engineering
- Energy science is essential
- Disciplinary knowledge is a key asset



Open up to other areas of science

- Pose new challenges
- Provide new models and methods

Take risks to adopt new areas early

- Establish and lead new research themes