Sustainable ICT at University of Luxembourg

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[Key challenges]

- Sustainable campuses
- Energy savings from direct and indirect energy use
- Monitor and anticipate energy consumption from the ICT facilities
- Carbon neutral ICT operations from the University's facilities

[Research priorities]

- Multi-objective optimization model of the energy consumption
- Learning, anticipation and prediction for usage scenarios
- Autonomic resource management
- Monitoring system of the energy consumption
- Resource allocation and load balancing

Carbon neutral ICT at the University of Luxembourg's facilities

Sustainability Unit: *http://www.uni.lu/university/sustainability*

2006-2007	A start to action on sustainable development at the University-level
April 2008	Joined the International Sustainable Campus Network (ISCN) that includes the ETH Zurich, the Universities of Copenhagen, Harvard, MIT, Berkeley, Tongji, and Tokyo. UL is also chairing one of the four working groups (Sustainable Development)
Mar. 2009	Dedicated UL Cell for Sustainable Development
Jan. 2010	Signed and committed to the ISCN-GULF (Global University Leadership Forum) Charter (21 Universities, including Harvard, MIT, ETH Zurich, Oxford and Cambridge)

Computer Science
Reducing energy consumption from our ICT equipment and operations

Engineering
A monitoring system for ICT-related energy consumption

Entrepreneurship
A business model for renewable energy management from photovoltaic resources

The future BELVAL Campus at the University of Luxembourg

Modeling

Modeled components:

- *User's activity, arrival of tasks or load dynamics* are modeled by relying on statistical data.
- *Stochastic factors*, e.g. weather change and solar energy drop or failures, are estimated online.

Outcomes:

- Multi-objective meta-model of the energy consumption, including dynamic and stochastic factors.
- Apply multi-objective paradigms in order to optimize energy consumption and reduce carbon footprint while maintaining a high level of performance.

Simulate

Dynamic, highly-complex systems: assessing the impact of a specific decision, e.g. percentage of renewable energy stored, becomes feasible if the evolution of the system over time can be simulated.

Scenarios: realizations of the system based on deterministic, dynamic factors or on previous knowledge obtained from the past states of the system.

Strategies: set of decisions to apply over a specified time window in order to ensure a high performance level with respect to the defined objectives.

On-going research

Experimental Prototype Laboratory, built upon:

- Virtualization, energy-efficient operation and allocation of resources;
- Autonomic management of renewable energy sources.

Workshop on GreenIT Evolutionary Computation

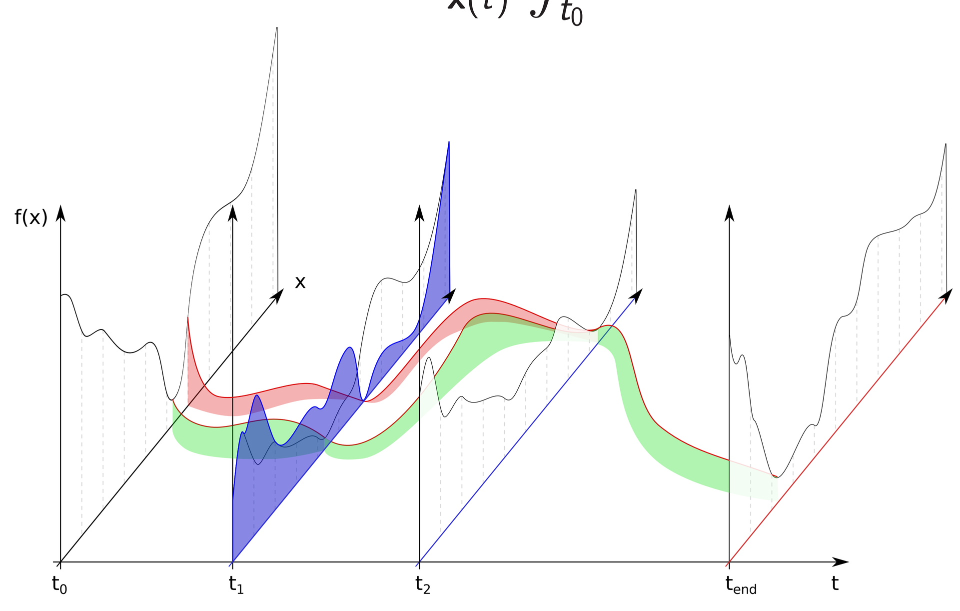
Low hanging fruits

Prototype laboratory expected to be implemented at a larger scale in the future Belval campus, Maison du Savoir building.

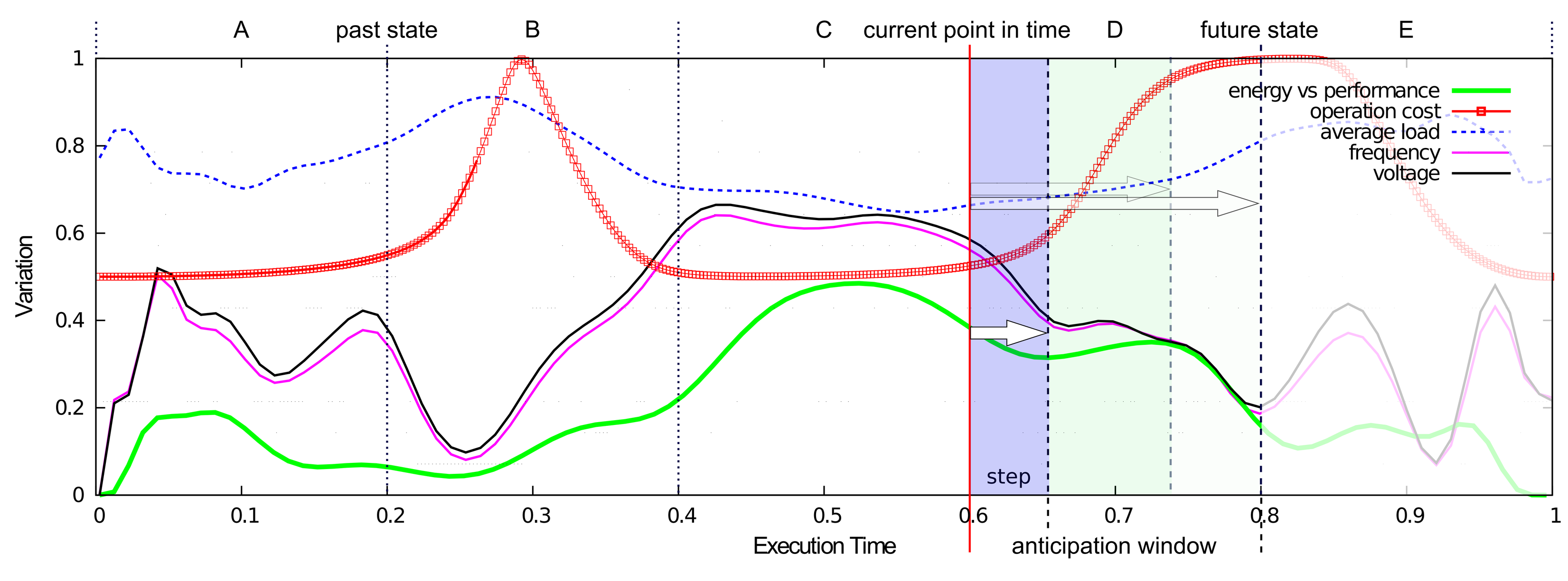
Learn and anticipate

Characteristics: *the environment σ changes dynamically with time.*

Optimization problem: $\min_{\mathbf{x}(t)} \int_{t_0}^{t_{end}} H(F_\sigma, T^{[t-j,t]}, x(t), t)\mathrm{d}t$



$F_\sigma : X \to Y$, $\arg\min_{x \in X} F_\sigma(x)$ vs $\arg\min_{\mathbf{x}(t)} \int_{t_0}^{t_{end}} F(\mathbf{x}(t), t)\mathrm{d}t$



Low-level measures – load and processing power optimization in a dynamic environment.

Impact and optimality of decisions: *when the state of a system depends on past states, the effects of a decision can propagate over time. An optimal decision for the current time moment may prove to be sub-optimal over a long time window. Anticipation thus relies on simulation models or on knowledge learnt from the past realizations of the system.*

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