# Introduction

## Motivation and Objectives

Worldwide data centers electricity consumption accounts for almost 2% of the world production and is expected to overcome the 40% of Total Cost of Ownership of worldwide IT by 2012[1] The U.S. EPA estimates that 1.5% of the entire electricity consumption in the U.S. is attributable to data centers. The same organization points out that the average data center is only 30% efficient, with 70% of the electricity lost due to inefficiencies of power and heat dissipation, along with powering cooling equipment [13]. The environmental impact of datacenter expansion is of great importance, every server using 7,000 kWh of electricity and indirectly generating four tons of carbon dioxide emissions per year [2].

The US Environmental Protection Agency estimated that in 2006 the servers and datacenters power consumption accounted for 61 billion kWh (**!! De introdus in acronime**) , about 1.5 % of total U.S electricity consumption and for a cost of $4.5 billion[3].

This has lead to the need of finding environmental friendly methods for managing datacenters while maintaining performance. This new research trend has been called Green IT or Green Computing. The philosophy of Green IT is designing and using computer resources in an environmentally friendly way. From the large number of research areas contained in this field this work has as aim reducing the overall number of servers used worldwide and further minimizing the number of powered on servers by applying server consolidation.

The main goal of this research is to develop an agent-based framework for dynamically adaptive datacenters which achieves server consolidation by combining server and task virtualization with a self-adapting datacenter controller. The framework should also provide a datacenter self-healing environment control mechanism. A secondary goal is finding new ways and methods of tradeoff between QoS and power consumption for further increasing server consolidation.

## Contributions

This project seeks to provide the necessary tool support for datacenter virtualization, consolidation, environment management and to develop new methods of negotiating between QoS and Power Consumption. There are both theoretical and practical contributions made by this project.

**Theoretical contributions**

* Develop a reinforcement-learning policy-based algorithm for autonomic self-healing environments. Adapt the previously mentioned algorithm for data center task management.
* Develop methods for negotiating between QoS requirements and Server Optimum Load Values (implying power consumption).

**Practical contributions**

* + - Create a datacenter management framework using policy-based mobile agents.
    - Develop tools for monitoring datacenter resources usage and environment sensors.
    - Find and evaluate appropriate technologies for implementing a self-adapting datacenter based on the framework mentioned above.

## Publications

The research conducted for this project has generated the following publications. The report chapters which include material from these publications are listed for each publication.

* + - **A Reinforcement Learning based Self-healing Algorithm for Managing Context Adaptation** [5] presents a reinforcement learning based algorithm use for finding the optimum sequence of actions which enforce some user-specified policies. A proof of concept implementation is also presented, which uses an X3D (**!!! De pus in lista de achronimes)** representation of a smart environment in which a user click on an object to change its state. The algorithm detects if a user-specified policy is broken, searches for the best (having the highest reward) sequence of actions which “repairs” the context and executes them. (**!!!!** Material from this paper can be found in **chapter2onpage7,Chapter4onpage31andChapter5onpage47**
    - **An Autonomic Algorithm for Energy Efficiency in Service Centers** [6] (!!!!**De modificat daca nu I acceptat)** is an adaptation of the algorithm presented in the previous paper to handle datacenter task management. The old algorithm is still used for monitoring the datacenter environment. Both algorithms are used in a proof of concept implementation which uses a simulated datacenter in which tasks are dynamically added and removed, triggering consolidation actions.

# Background

This chapter provides an overview of the background theory in the area of Self-\*(configuring, healing, optimizing, protecting) Systems and Green Computing specific to the requirements of this project.

The following topics are discussed:

* An introduction to Intelligent Agents and Pervasive Computing
* An introduction to Green Computing, Virtualization and Server Consolidation
* An overview of Artificial Intelligence Learning, Knowledge Representation and Reasoning
* An overview over existing negotiation and bargaining solutions.

## Intelligent Agents and Pervasive Computing

### Introduction

Pervasive computing, also named as **everywhere computing** or **ubiquitous computing** [6] is a computing paradigm in which information processing has been integrated in everyday life by means of small networked processing devices. These devices link communications and computing infrastructure to everyday life settings and commonplace tasks[7].

Agents are defined as anything perceives its environment through sensors and performs actions on that environment through actuators [7].

## Agent Environment

By their nature, the environments are roughly classified by [8] in:

**Fully observable and partially observable environments:** As the name suggests, in fully observable environments the agent has all the needed information, while in partially observable not everything about the context is known.

**Deterministic and Stochastic environments**: In a deterministic environment the next state is determined entirely based on the current state and the action executed by the agent.

**Episodic and Sequential environments**: in an episodic environment there are independent episodes, while in sequential ones the next world state is always influenced by the previous one.

**Static and Dynamic environments**: In a static environment the world does not change while the agent thinks what to do.

**Discrete and Continuous environments**: Discrete environments have a finite number of states.

**Single-Agent and Multiple-Agent environments**: In multiple-agent environments agents compete for a set of resources.

## Agent Types

Based on the complexity of the agent’s reasoning process the agents are classified in 5 categories [8]:

**Simple reflex agents:** Act only based on the current input data, ignoring the context history. The agent’s actions are determined by simple rules. Such an agent can succeed only in fully observable environments where each.

**Model-based agents:** This type of agents maintains an internal model of the world in order to be able to reason over partially observable environments. The model holds previously observed information that now is not observable anymore and reacts just as the simple reflex agent to input data.

**Goal-based agents:** Because in complex situations just reacting will not lead to the desired outcome this type of agent has appeared. These agents know some **goal states** and will try to reach those states.

**Utility–based agents:** Knowing about just the goal does not provide a measure of degree of how expensive is a set of actions the concept of utility is introduced. A **utility function** is used to map each an environment state to a desirability value, thus the agent being capable of comparing two courses of action and choose the one with the highest utility.

**Learning agents:** Are the most complex and can operate in unknown environments. These agents learn about the surrounding world as they go and continuously adapt themselves.

# Problem description and statement

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# Theory

# Methods

# Results

# Related Work

# Conclusions

# References

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[3] VMware Whitepaper : How VMware Virtualization Right-sizes IT Infrastructure to Reduce Power Consumption, <http://www.vmware.com/files/pdf/WhitePaper_ReducePowerConsumption.pdf>, pages 4

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[7]

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