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Research results of the GGC-LAB project

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Project summary

Project title:	GGC-LAB - Government Green Cloud Laboratory
BMWi code:	01 ME 11035A
Term:	01/06/2011 to 30/11/2014
Consortium:	regio iT - Gesellschaft für Informationstechnologie mbH
	Dataport
	kom21 - Municipal Area Data Centre Hesse
	Brandenburg IT service providers (ZIT-BB)
	StoneOne AG
	Technical University of Berlin
Project director:	Bernhard Barz, regio IT
Website:	www.ggc-lab.de

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Research topics

Analysis of relevant factors for the realization of energy-efficient cloud computing in the public sector:

- Assessment of the cloud capability of municipal application software
- Legal framework for the load shift between facilities in different locations (in different states)
- Incentives such as variable electricity prices, renewable energy use

Development of methods for the control system and targeted shifting of IT loads among multiple data centres:

- Comprehensive measurement of power consumption in participating data centres
- Use optimisation of the capabilities of a data centre network
- Potential of pooling of IT resources across data centres
- Performance indicators in support of an effective control system

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Cloud-capable municipal specialised applications

In this project the cloud capability of municipal specialised applications, that is, the use of these applications through a web/browser interface, is investigated:

- Currently very few municipal specialised applications are cloud capable
- There is also a great number of software solutions for similar specialised applications (low compatibility, structures that grew up over time)
- Virtualisation of specialised applications is currently only very limited due to data protection and safety regulations
- Specialised applications typically run on dedicated servers, with the result that some have a utilization of only 2%
- There is high theoretical potential for reducing the number of physical servers (consolidation) and thus improving energy efficiency, if such a move would be allowed by procurement as well as data protection rules

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Analysis of the legal framework

In the project, the legal framework for targeted migration of municipal specialist applications was examined:

- The load shift (migration) between spatially separated and institutionally different data centres in itself is not a problem as long as the requirements of procurement law, data protection and other contractual provisions are complied with
- Data protection laws currently do not allow IT-based processing of personal data or its transfer from the municipal level to the state or federal level. Commingling of data of different states must be avoided under all circumstances
- Outsourcing of specialist applications to data centres of the private sector (IT service provider working on behalf of a municipality or state) is also inhibited for social and tax law reasons, along with data protection

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Cloud network and process sequences

Models of process sequences and organisational structures were drafted among the cloud participants:

- An actor/role model which reflects the interaction among themselves of all the providers and their roles. Based on this model, the control mechanism and incentive system is to be developed
- A collection of cloud application scenarios and a customer list of requirements will serve as a basis for the incentive system
- A behaviour diagram for the control mechanism is developed using UML notation and implemented in a manner proximate to the actual implementation
- A cloud value process model, in which the actor/role model is integrated and value-added services and support activities are shown (topics include software licenses and other costs)

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Operating mode of the cloud network

The practical design of a cloud network was analysed:

- Network with partners in Berlin, Potsdam, Kassel, Aachen and Hamburg
- Network connection via encrypted Internet/VPN, as this is more cost-effective than a leased line or DOI (network management)
- Challenges include long signal propagation times (> 10ms to < 1000ms), which makes database applications (synchronisation) more difficult
- A distributed control system for the network was given priority. However, the benefits could not be quantified precisely
- Extensive set of policies
- Development of control indicators and resource controllers
- Selection of three specialised applications for testing migration:
  - PTRAVEL (travel expense report)
  - Votemanager (elections)
  - VOIS (residence registration)

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Technical development of the GGC laboratory environment

The investigation of the energy efficiency of a data centre network (Community Cloud / Green Government Cloud) was implemented in a separate laboratory environment in parallel to production operation of the data centres involved:

- Design of the sub-cloud, including:
  - Development of a resource controller (StoneOne AG)
  - Development of a reverse proxy based on nginx (regio iT)
  - Development of energy monitoring based on NAGIOS (regio iT)
- Definition of policies for the control system (TU Berlin)
- Design and exemplary realisation of the cloud network (community cloud), including the complete logical network structure in the WAN (VPN) (Dataport)

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Detailed measurement of electricity consumption

The survey of the energy requirements of functional IT systems and individual consumer groups forms the basis of the measurements

- At the beginning of the project, there was no monitoring system at any of the data centres (DC) that could provide the resource controller with all information (including power requirements) via a standardised interface
- The plans included measurement of IT loads and power consumption in four data centres, including calculation of PUE (Power Usage Effectiveness)
- Defining and locating the measuring points was extremely time consuming
- The system-wide monitoring system (based on Nagios) integrates different data sources, harmonises (time, format), stores the data and prepares it in the form of figures
- The measurement campaigns were up to one year (good data basis)

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Evaluation of the measurement results

Significant measurement results:

- During the year, the power consumers in the data centre, including IT, cooling systems and free coolers, were not dynamic in their behaviour
- Over the months, there were regular periods of low utilization (metastable day/night cycles and working-day/weekend cycles)
- The total power consumption of the measured data centres usually increases only modestly during active daytime use. This is due to very low utilisation of IT resources and a permanent standby state
- Cooling is a significant energy consumer and responds to seasonal changes (summer/winter)

Conclusion: The measurement results were sobering in part, showing the low load adaptivity of the IT technology on the one hand and suboptimal design of the cooling infrastructure on the other

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Making use of the results

- The first practical list of requirements for cloud capability of (municipal) applications (incl. legal and contractual requirements)
- Decentralised control software (resource controller) which enables optimisation of resource utilisation across data centres from an energetic point of view
- Establishment of a reference architecture for a cooperating cloud network of municipal data centres

Potential

- With the same IT technology, computing loads are consolidated in the direction of the data centre with the lowest EUE (savings of up to 40%)
- A shift is worthwhile in terms of energy only if the IT resources can be used more dynamically in the participating data centres