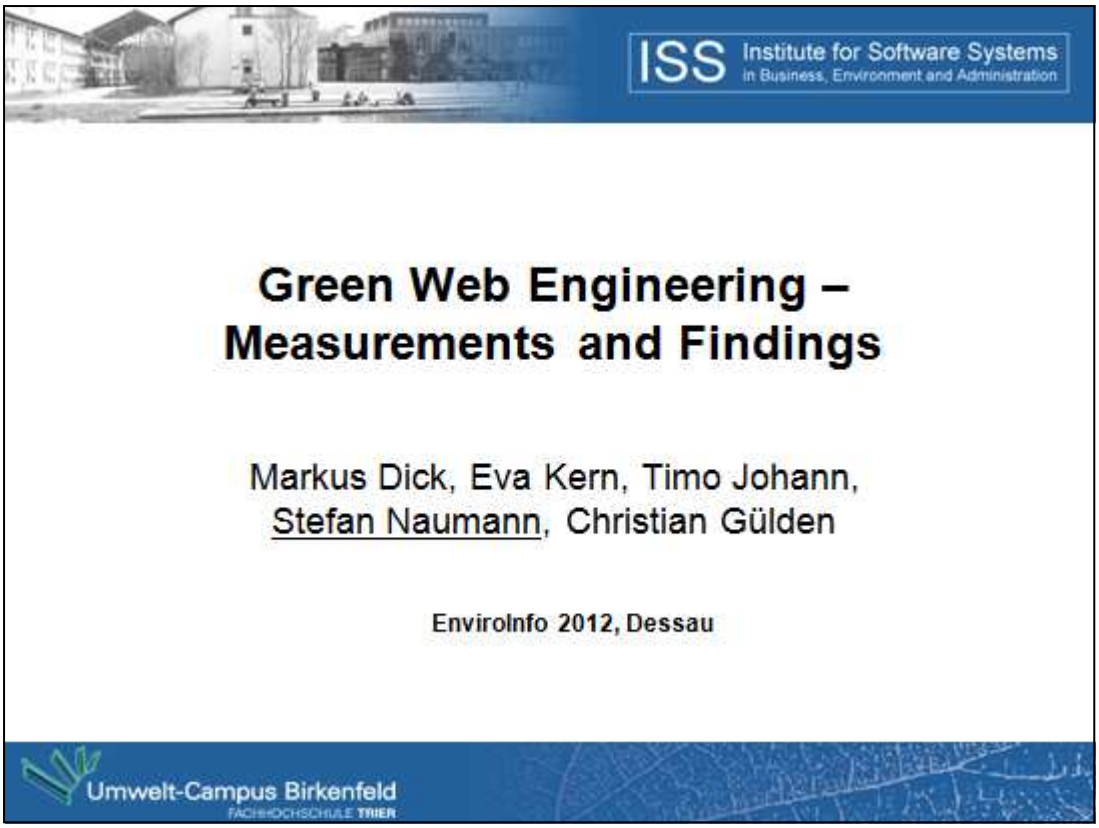

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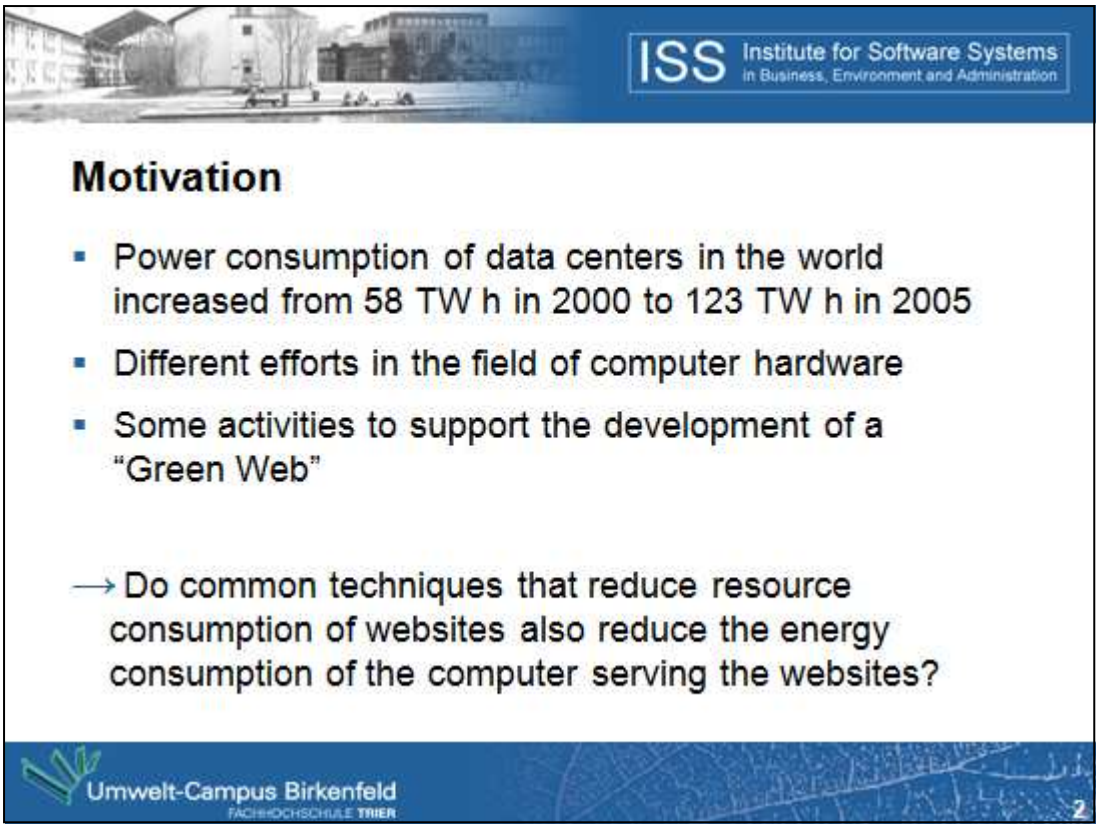
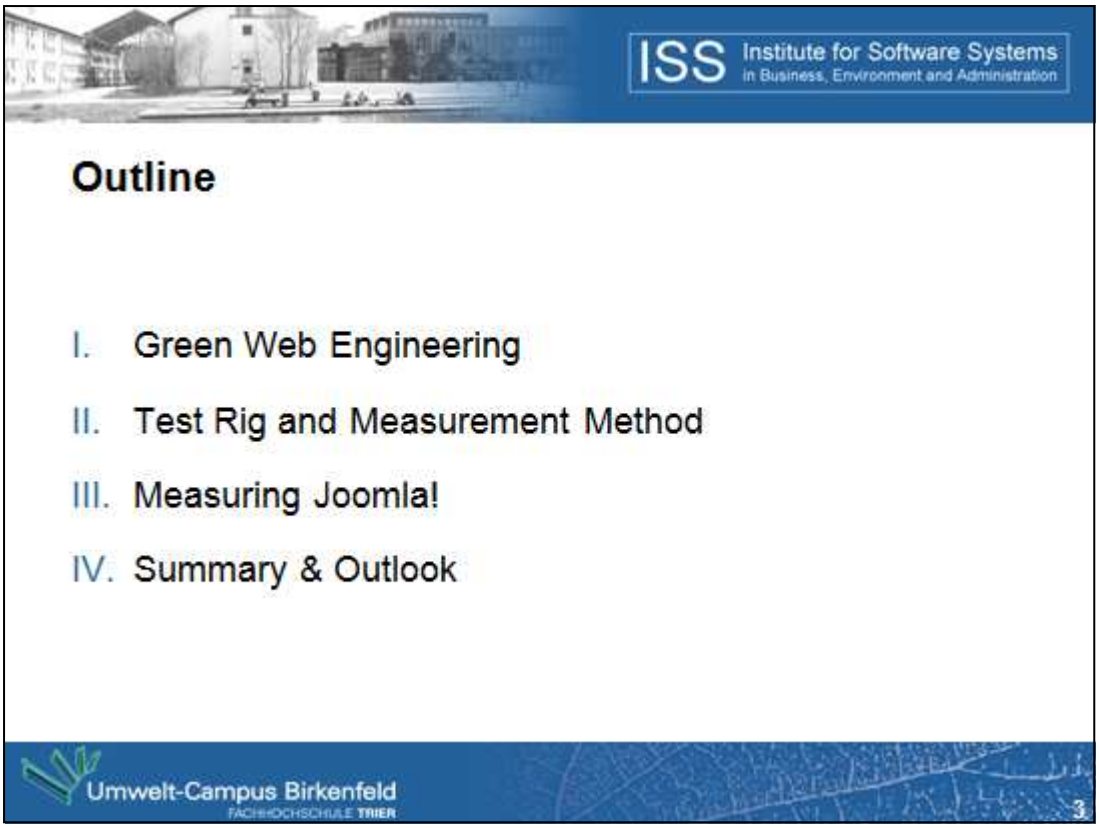
This presentation corresponds to the following paper:

Dick, Markus; Kern, Eva; Johann, Timo; Naumann, Stefan; Gülden, Christian (2012): **Green Web Engineering - Measurements and Findings**. In: Arndt, Hans-Knud; Knetsch, Gerlinde; Pillmann, Werner (Hg.): EnviroInfo 2012: Man Environment Bauhaus: Light up the Ideas of Environmental Informatics. Proceedings of the 26th International Conference on Informatics on Informatics - Informatics for Environmental Protection, Sustainable Development and Risk Management, Part 2; Federal Environment Agency, Dessau, 2012. Volume 1. Aachen: Shaker Verlag, pp. 599–606.



The power consumption of data centres in the world increased from 58 TW h in 2000 to 123 TW h in 2005, and is still increasing.
Hence, reducing the consumption of energy and natural resources caused by ICT is necessary.
Where manifold efforts exist in the field of computer hardware (that is: Green-IT), there is a lack of efforts in the field of computer software.
Therefore, methods are necessary that enable different stakeholders like developers, purchasers, administrators or even users to consider energy consumption induced by software in their decisions on software products.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Outline
I. Green Web Engineering
II. Test Rig and Measurement Method
III. Measuring Joomla!
IV. Summary & Outlook
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I. Green Web Engineering
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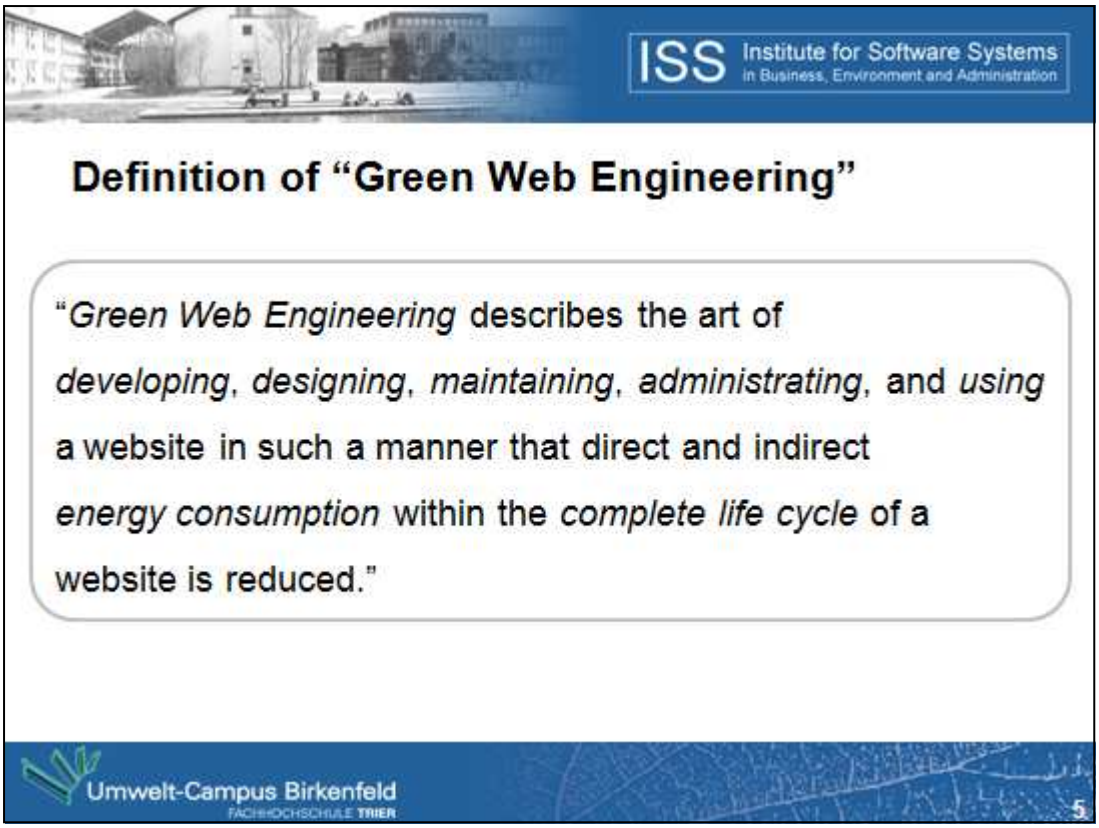
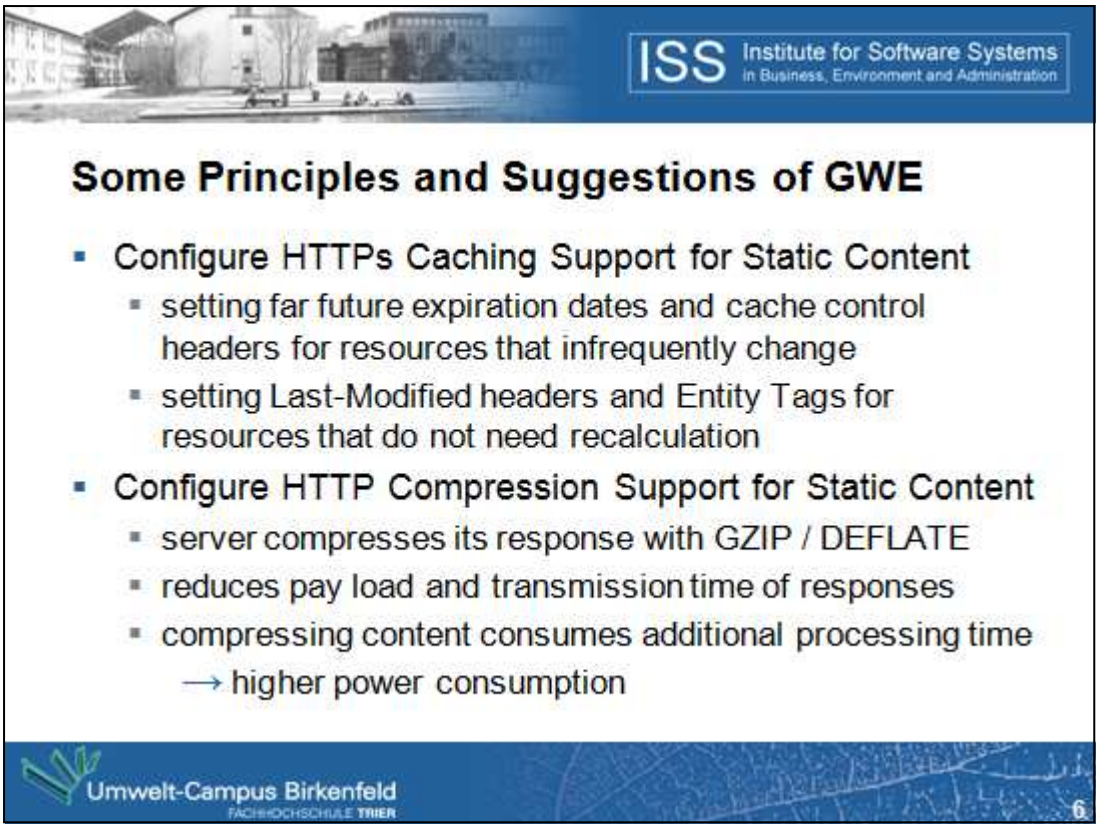


Direct energy consumption or the so-called "first order effects" comprises energy consumption that is caused by the infrastructure, which is necessary to provide the service or to present the website to the end-user. This includes data centre and networking infrastructure as well as the infrastructure on the client-side.
Indirect energy consumption is also called "second" and/or "third order effects" or "enabling effects". This means that the service offered by a website may be an enabler of change in production processes or consumption with the potential to mitigate environmental impacts. For example a service can help to better organize traffic or to replace traffic, which has a positive effect on the environment.
However, a service may also cause negative effect on the environment, for example if it generates additional demand for traffic.



For Administrators we suggest to

• Configure HTTPs caching support properly.

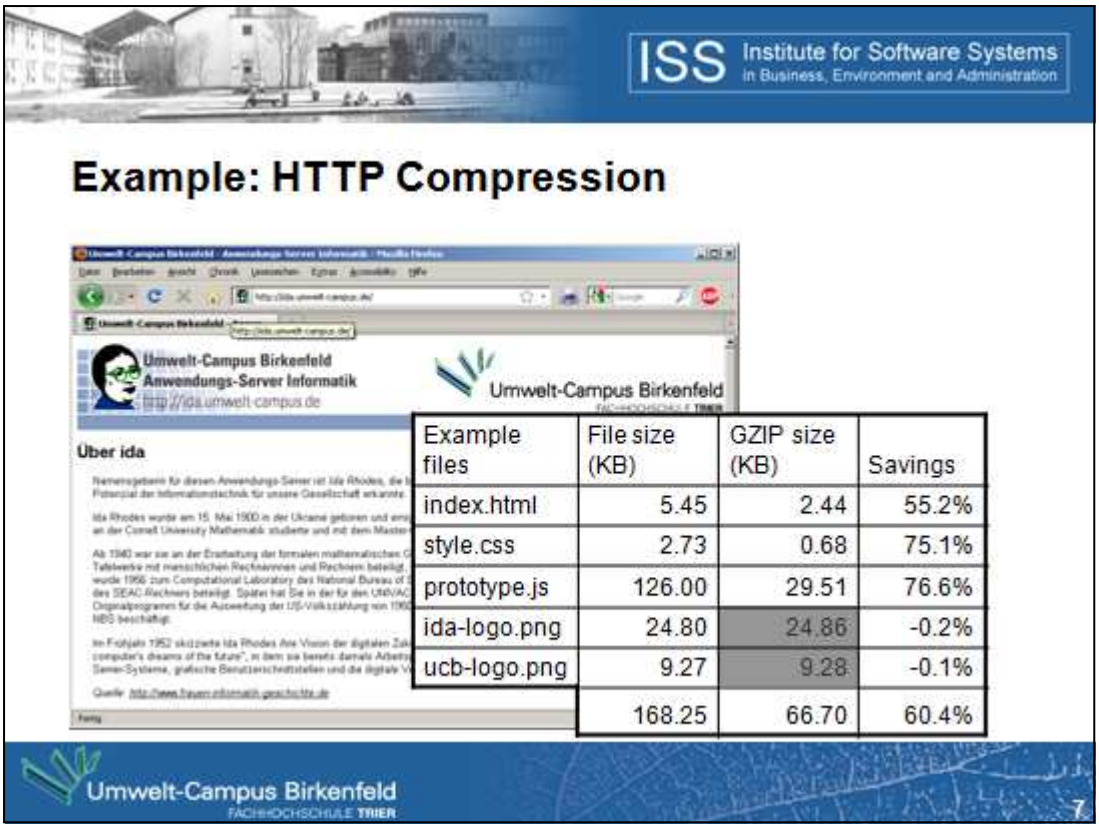
• That means: setting far future expiration dates and cache control headers for resources that infrequently change.
That's the so-called "expiration mechanism".
For example, Google Germany uses for its logo expiration dates of one year ahead in the future.

• Further we suggest to set Last-Modified headers and Entity Tags for all resources that do not need recalculation on subsequent requests.
That's the so-called "validation mechanism".
This applies mainly to static content.

Both mechanisms enable properly configured browsers to cache content effectively and to reduce the amount of transferred data on subsequent requests, which reduces energy consumption

• Furthermore we Suggest to use HTTP compression and

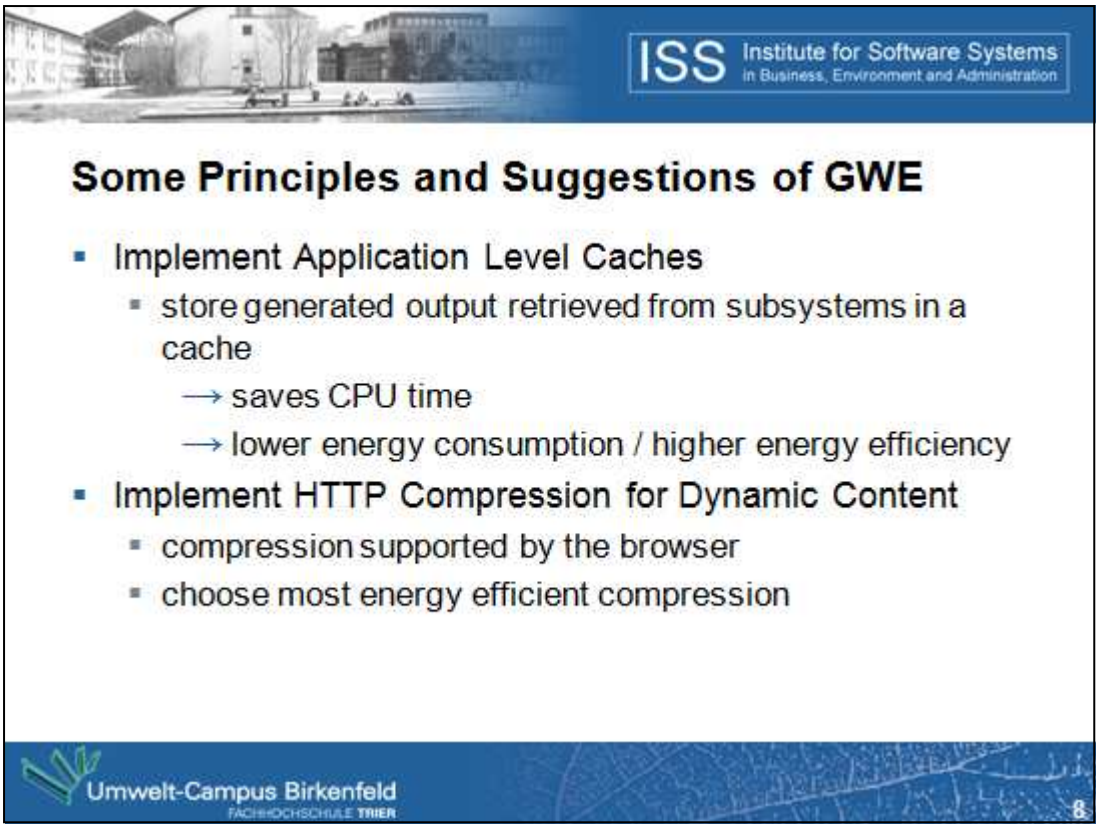
• To apply classic "green IT" concepts like server virtualisation or webhosting with renewable energies.



Example files	File size (KB)	GZIP size (KB)	Savings
index.html	5.45	2.44	55.2%
style.css	2.73	0.68	75.1%
prototype.js	126.00	29.51	76.6%
ida-logo.png	24.80	24.86	-0.2%
ucb-logo.png	9.27	9.28	-0.1%
	168.25	66.70	60.4%

For Example HTTP Compression...
By enabling HTTP Compression we achieved for this simple example website, which comprises five files, data transfer savings from 50 to 76 per cent depending on the file type.
It is clear that files which contain many repetitions like the JavaScript file in this example, are better compressible than those with less repetitions like the HTML file.
It is also clear that compressing already compressed files like the two image files is even counterproductive so that these files should not be compressed again by the web server.

Compressing the data stream reduces the transfer volume and thus reduces power consumption.
But compressing the data stream on the fly depending on the capabilities of the user's web browser may lead to a higher processor usage and thus possibly increases power consumption.
Hence, we suggest to pre-compress static content wherever possible and to configure the web server in such a manner that it serves the pre-compressed or uncompressed versions depending on the capabilities of the browser.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Some Principles and Suggestions of GWE
Implement Application Level Caches
store generated output retrieved from subsystems in a cache
→ saves CPU time
→ lower energy consumption / higher energy efficiency
Implement HTTP Compression for Dynamic Content
compression supported by the browser
choose most energy efficient compression
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Some Principles and Suggestions of GWE

- Optimize Graphical Elements, Logos and Photographs
  - **graphical elements** or logos: PNG format instead of JPEG (better compression algorithm)
  - indexed palette instead of RGB full colors
  - realising text by CSS and HTML
  - **photographs** stored in JPEG format
  - blurring areas of an image that do not carry important information

Example: Optimizing Graphical Elements

Color Palette	Size(KB)	Savings
with text		
RGB	13.3	0%
without text		
RGB	5.47	58.9%
256	2.70	79.7%
16	1.15	91.3%
10	0.99	92.6%

PNG graphic in RGB colors with text vs. graphic with 10 color indexed palette, text is put to the foreground with means of HTML and CSS

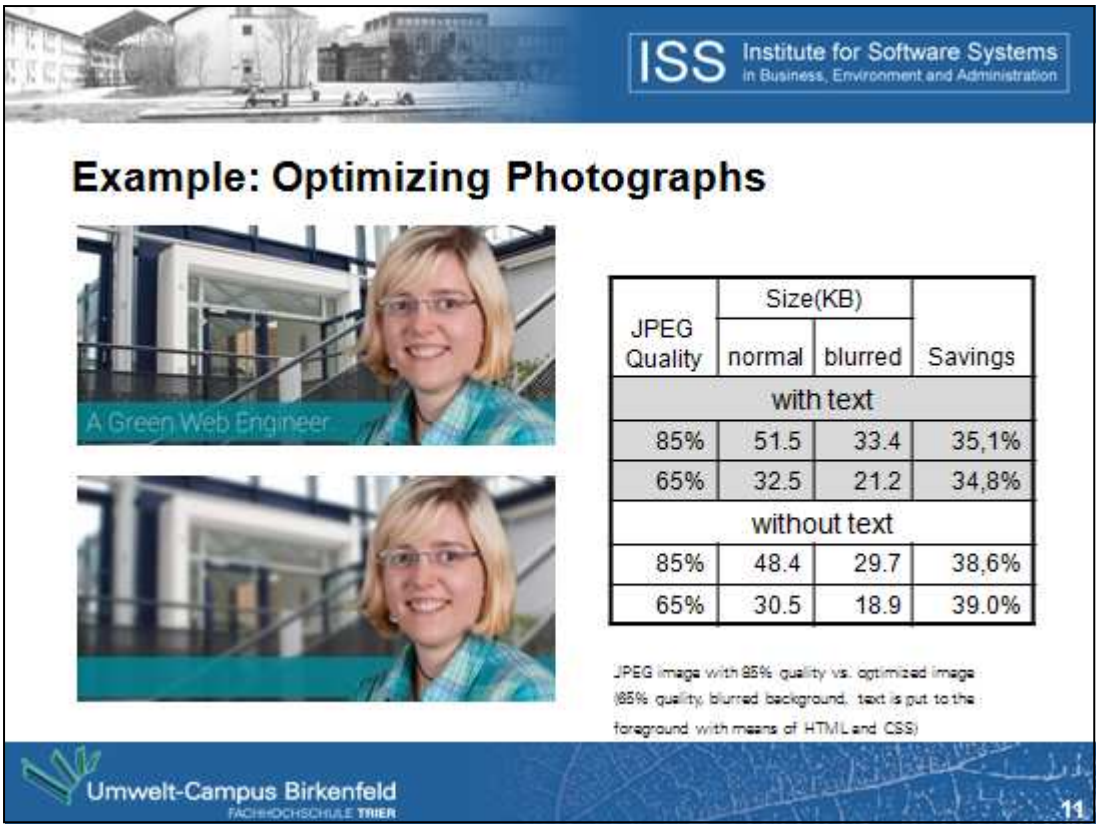
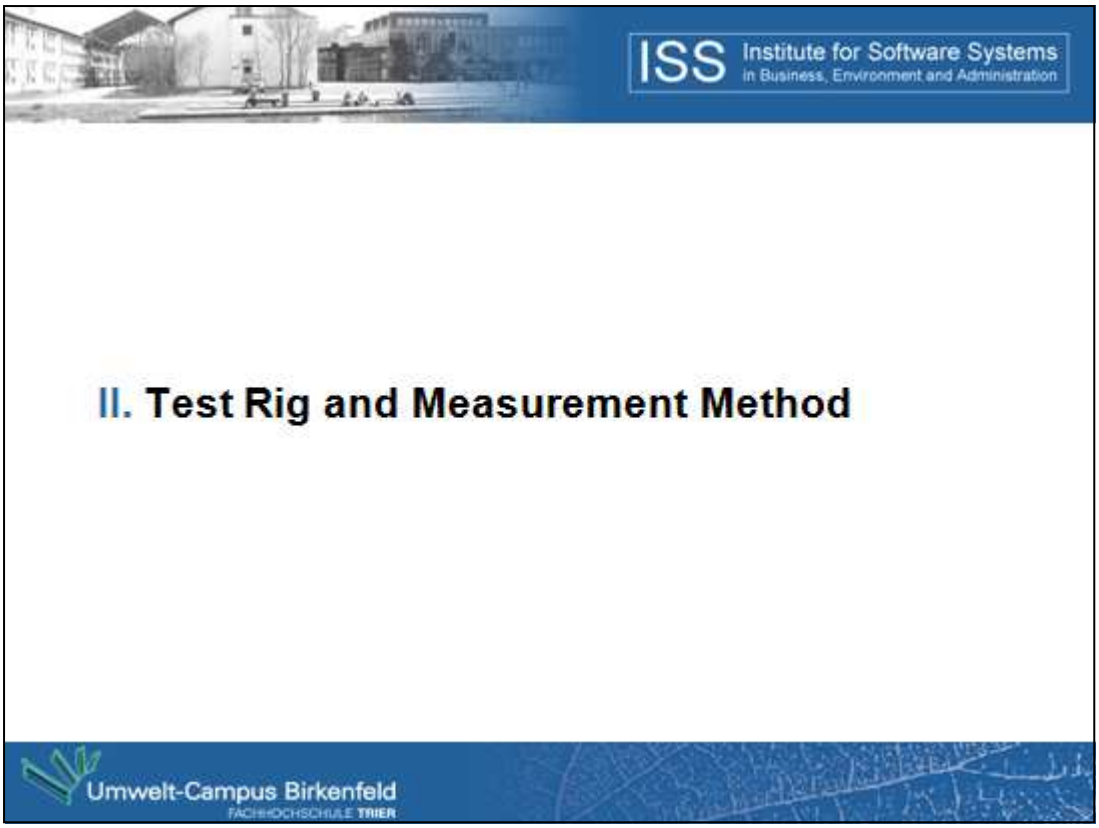


photo 1: 85%, with text + BG: 51.5 KB
photo 2: 65%, without Text + blurred BG: 18.9 KB
=> Savings: 63,30%

The second example shows how an advertisement image or a photograph in JPEG format can be optimized.

The relevant content of this image is the person and the blue banner in the foreground. The blue banner may be overlaid with an advertising slogan. The background transports no necessary information for an observer.

So, blurring the background supports JPEGs compression algorithm which results in a lower file size.
For this example which was stored at 80% JPEG quality we achieved file size savings of 47% compared to the normal files size simply by blurring the background.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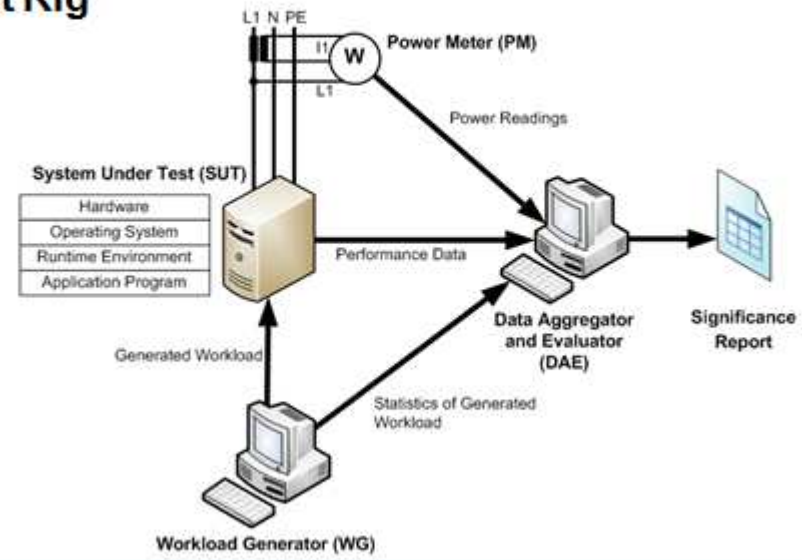
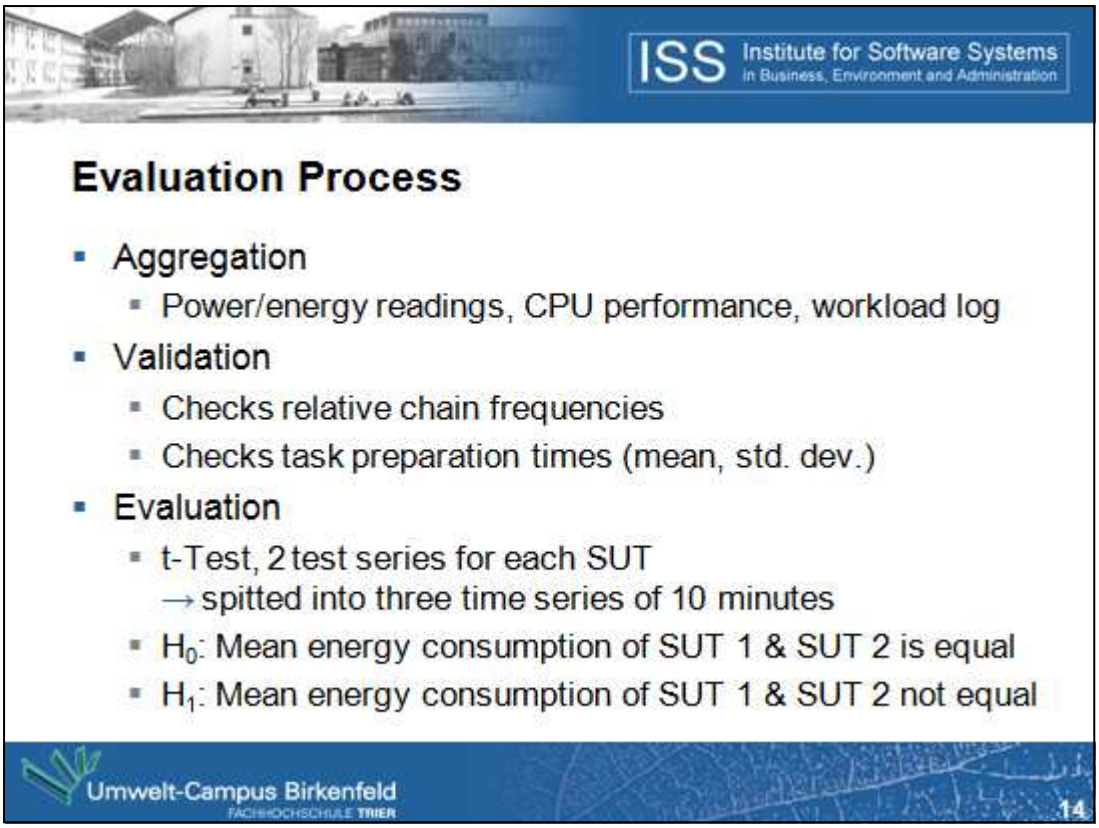
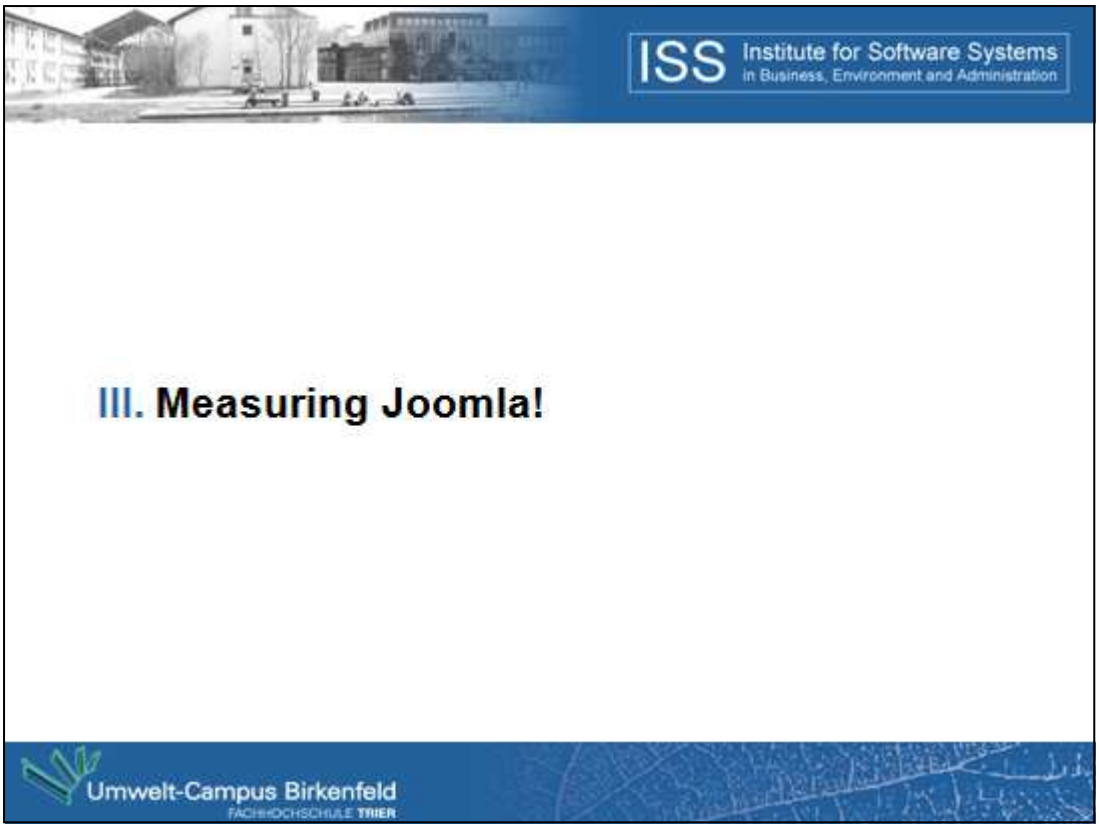
Test Rig


L1 N PE
I1
L1
W
Power Meter (PM)
Power Readings
System Under Test (SUT)
Hardware
Operating System
Runtime Environment
Application Program
Performance Data
Data Aggregator and Evaluator (DAE)
Significance Report
Generated Workload
Statistics of Generated Workload
Workload Generator (WG)



Validation:
Answers the question if generated workloads comply with parameters predefined in the workload definition
For each of the three values, the maximum acceptable tolerance is given.
The validations are done for each user type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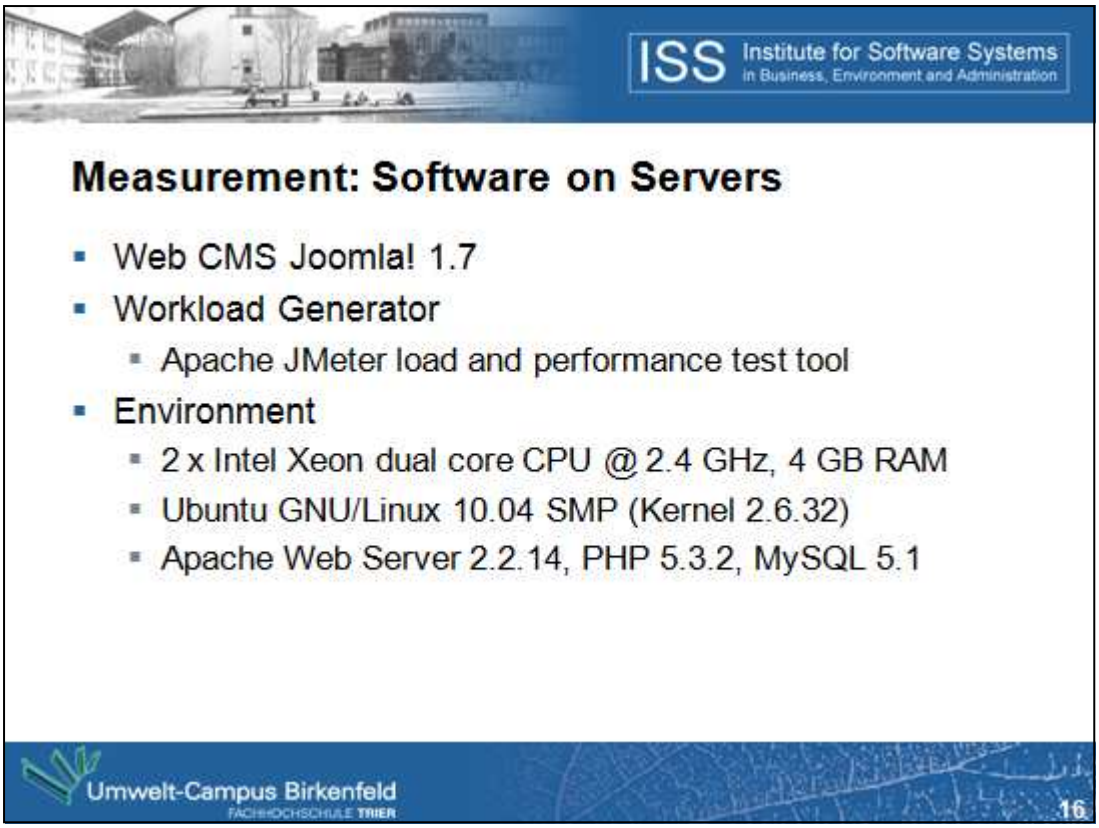
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Measurement: Software on Servers
Web CMS Joomla! 1.7
Workload Generator
Apache JMeter load and performance test tool
Environment
2 x Intel Xeon dual core CPU @ 2.4 GHz, 4 GB RAM
Ubuntu GNU/Linux 10.04 SMP (Kernel 2.6.32)
Apache Web Server 2.2.14, PHP 5.3.2, MySQL 5.1
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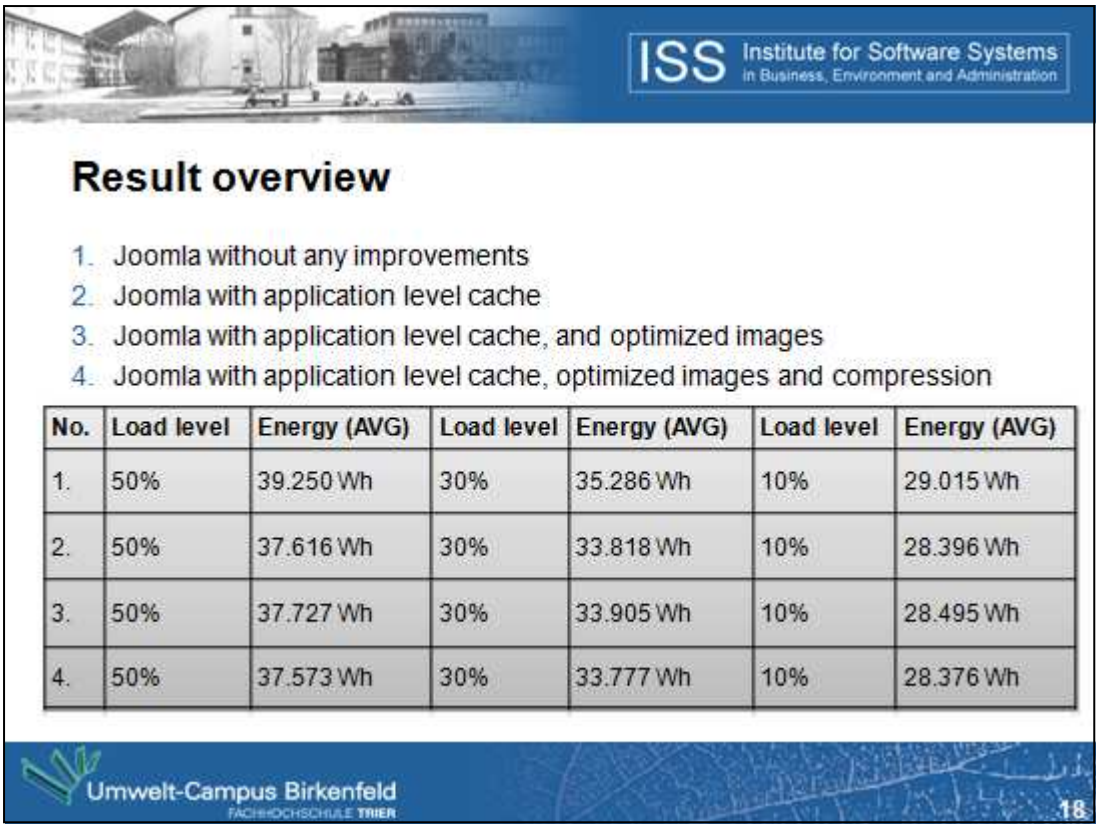
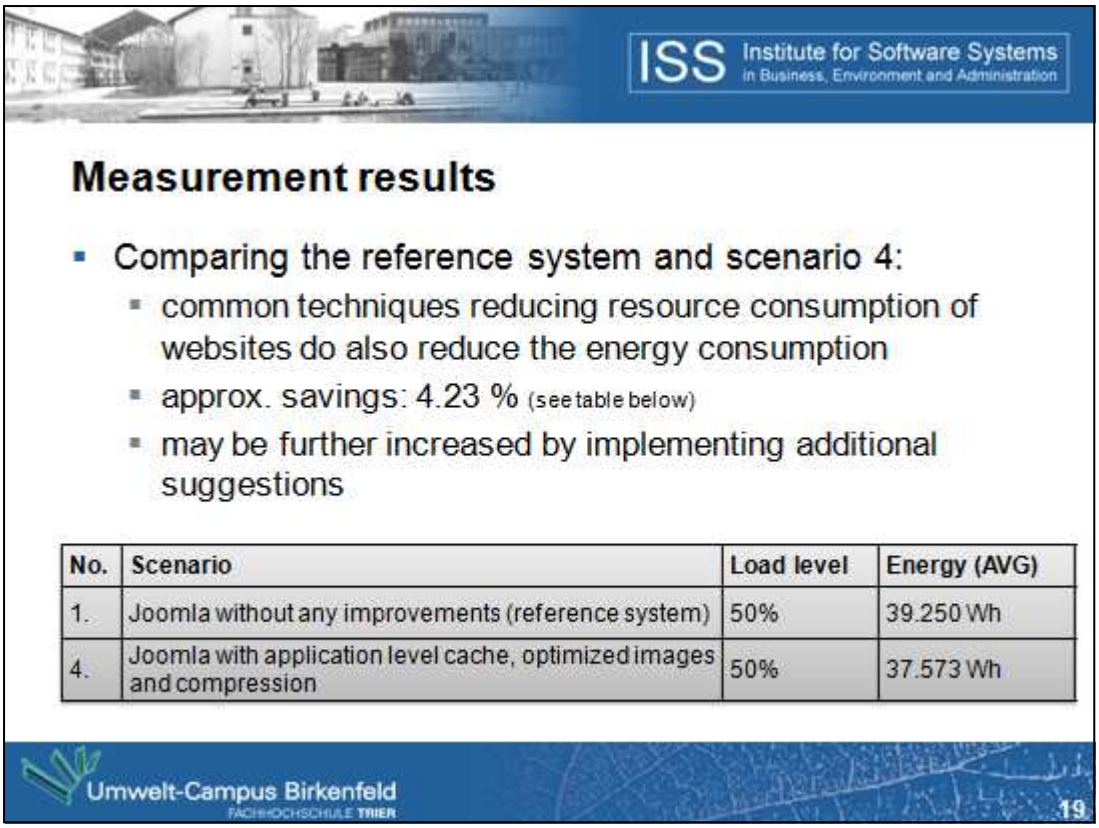
Setup of the Testing Website

- Content:
  - text passages from EU legal documents
  - self-taken photographs
  - graphics from R&D project
- Navigation area:
  - 10 articles without optimized images
  - 10 articles with optimized images
  - list of 100 generic articles to simulate paging



Projection to one year of 24/7 operation:
savings 153,9 kWh/a = 30,78€/a (0.20€/kWh)

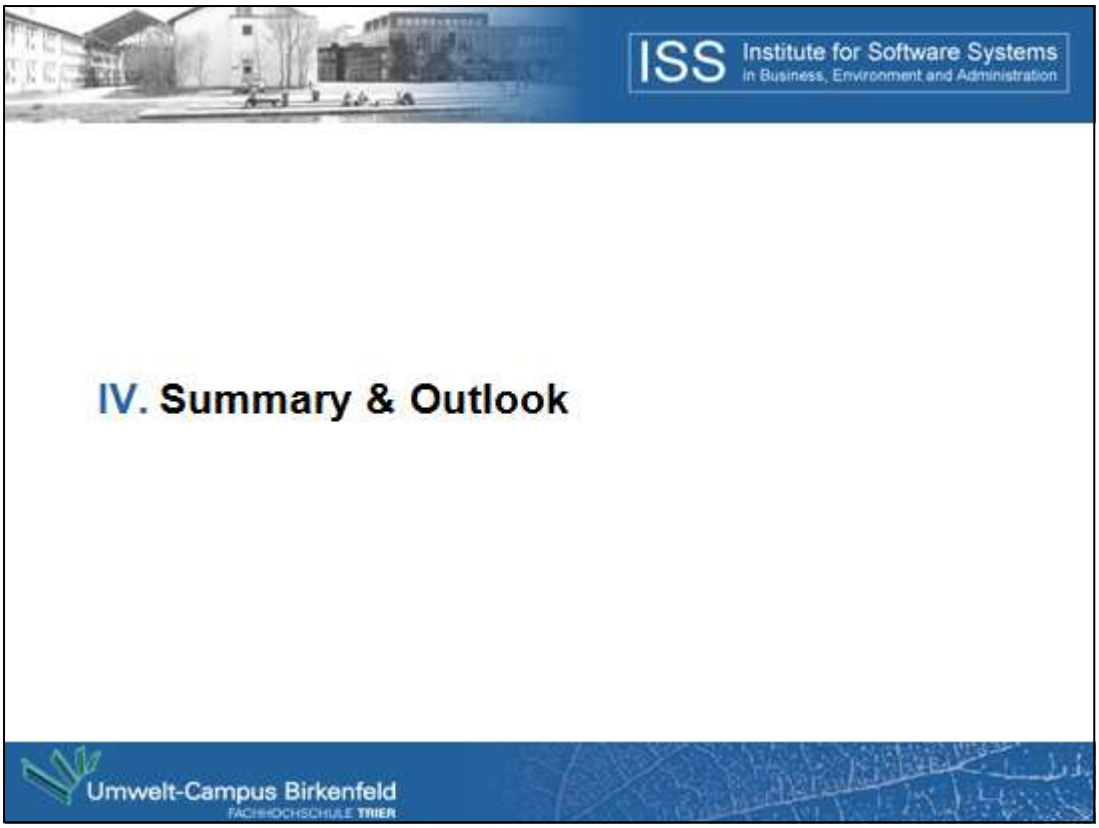
Hochrechnung 1 Million Nutzer



WCMS and webapps should provide application level caches so that there is no need to query the database for each request (data that is often requested should be hold in the cache, whereas there is no need to cache data that is seldom requested)
WCMS and webapps should support compression for static text based or already uncompressed content. Static content should be compressed in advance so that the stream is not compressed for each request (which consumes CPU time and energy)
WCMS and webapps should support compression of dynamically generated responses
Even if not checked in this paper, WCMS and webapps should support browser caches to prevent repetitive downloads of an unaltered resource in subsequent requests
WCMS and webapp development tools should provide tips and hints for authors, administrators, and developers on how to improve resource consumption of images, accessibility of images for impaired people, or on update strategies

Findings

- Enable application level caches in order to reduce database queries
- Enable compression for static text or already uncompressed content, if possible in advance
- Enable compression for dynamically generated responses
- Support browser caches to prevent repetitive downloads of an unaltered resource in subsequent requests
- Enable tips and hints in IDE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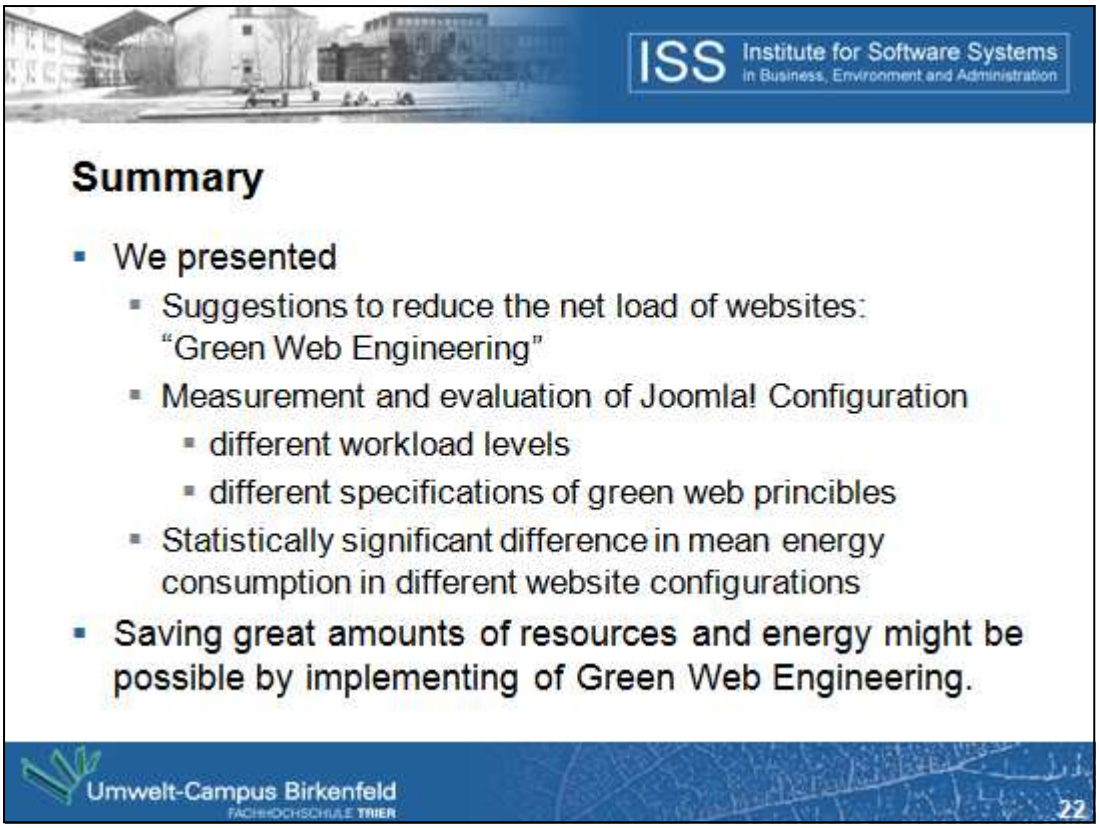
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Summary
We presented
Suggestions to reduce the net load of websites: "Green Web Engineering"
Measurement and evaluation of Joomla! Configuration
different workload levels
different specifications of green web princibles
Statistically significant difference in mean energy consumption in different website configurations
Saving great amounts of resources and energy might be possible by implementing of Green Web Engineering.
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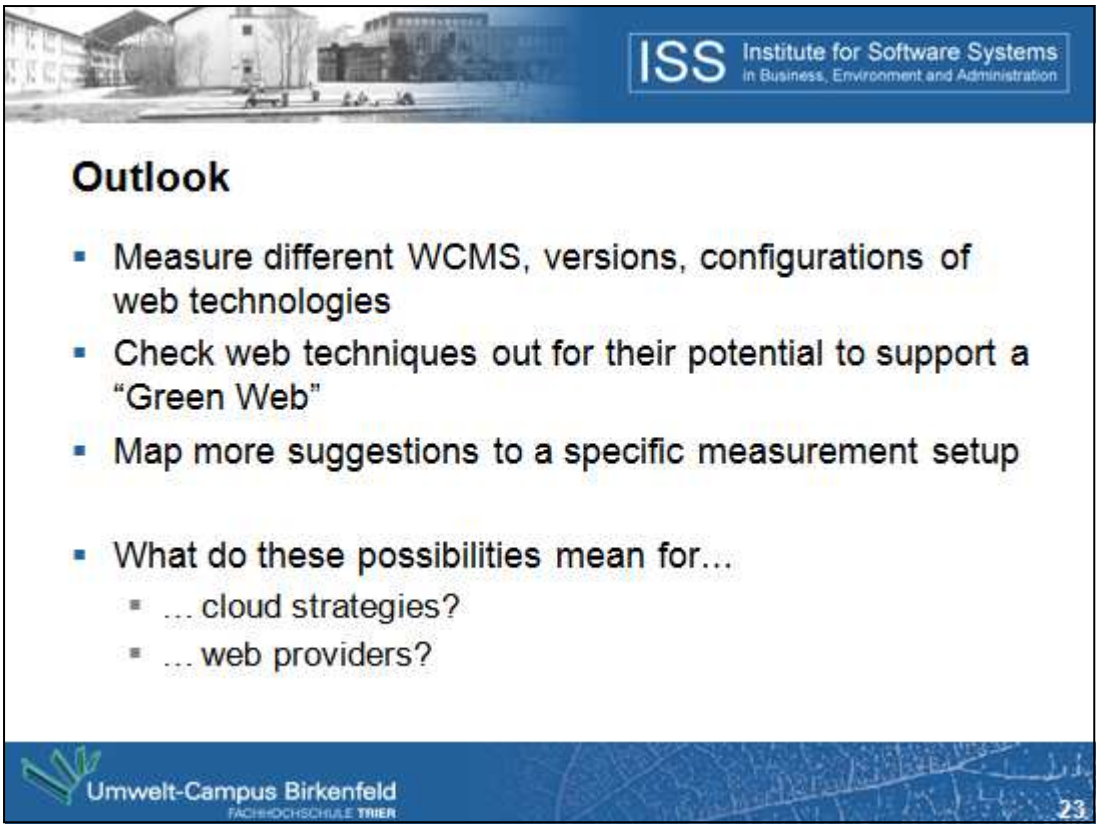
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Outlook
Measure different WCMS, versions, configurations of web technologies
Check web techniques out for their potential to support a "Green Web"
Map more suggestions to a specific measurement setup
What do these possibilities mean for…
… cloud strategies?
… web providers?
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If you have further ideas or suggestions on how to improve the measurement and rating method,

feel free to contact us at the Environmental Campus Birkenfeld of the Trier University of Applied Sciences in Germany.

Thank you very much for your time and attention.