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Lecture 13

Evaluation of Mobile Application & Service Designs

Mobile Business II (SS 2008)

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Agenda

- Introduction
- Case Studies
- Dynamic Analyses
- Controlled Experiments
- Simulations
- Summary & Conclusion

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Introduction to Design Evaluation

- Evaluation of application and service designs is difficult since such evaluations address objects that currently exist as concepts or prototypical implementations only.
- Therefore, design evaluations represent *ex ante* evaluations of IT investments into corresponding technologies. [Muntermann and Janssen 2005]
- Consequently, design evaluation addresses the *potential value* of IT design deployments

[Davern and Kauffman 2000]

Introduction to Design Evaluation

- The selection of appropriate evaluation methods needs to be matched with the application or service design.
- For example, descriptive evaluation methods are appropriate for especially innovative designs for which other (e.g. quantitative) evaluation approaches may not be feasible.
- The goodness and efficacy of designs can be rigorously demonstrated via well-selected evaluation methods.

[Hevner et al. 2004]

Design Evaluation Methods

Observational	Case study	Studies artifact in depth in business environment
	Field study	Monitors use of artifact in multiple projects
Analytical	Static analysis	Examines structure of artifact for static qualities (e.g. complexity)
	Architecture analysis	Studies how artifact fits into technical IS architecture
	Optimization	Demonstrates inherent optimal properties of artifact or provides optimality bounds on artifact behavior
	Dynamic analysis	Studies artifact in use for dynamic qualities (e.g. performance)
Experimental	Controlled experiment	Studies artifact in controlled environment for properties (e.g. usability)
	Simulation	Executes artifact with artificial or historical data
Testing	Functional (black box) testing	Executes artifact interfaces to discover failures and identify defects
	Structural (white box) testing	Performs coverage testing of some metric (e.g. execution paths) in the artifact implementation
Descriptive	Informed argument	Uses information from the knowledge base (e.g. relevant research) to build a convincing argument for the artifact's utility
	Scenarios	Scenarios: Construct detailed scenarios around the artifact to demonstrate its utility

[based on Hevner et al. 2004]

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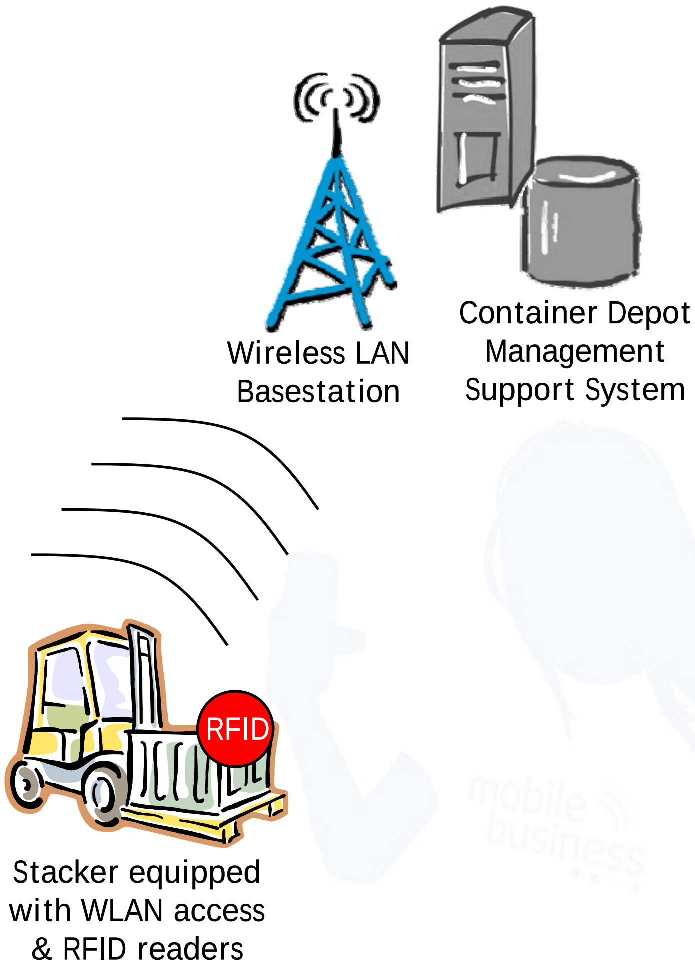
Example 1: An Integrated RFID-based Mobile Logistics System Design

- The Container Depot Management Support System (CDMSS) is designed to support a container depot using RFID and mobile communication technologies.

- Containers are automatically identified by the stackers via RFID tags, and stackers continuously communicate with the CDMSS via WLAN.

➲ Real-time visibility of container positions enables operators to process containers more quickly and efficiently.



[Ngai et al. 2007]

Evaluation Approach: Case Study

- The integrated RFID-based system design is evaluated by conducting a case study.

Observational	Case study	Studies artifact in depth in business environment
	Field study	Monitors use of artifact in multiple projects

- A case study is "an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident". [Yin 2003]
- As case study company a container depot located in Hong Kong was chosen (Container System Ltd. with a size of 21,000m^2).
- This company operates a traditional computer information system, which does not support mobile communication technologies so far.

[Ngai et al. 2007]

Evaluation Approach: Case Study

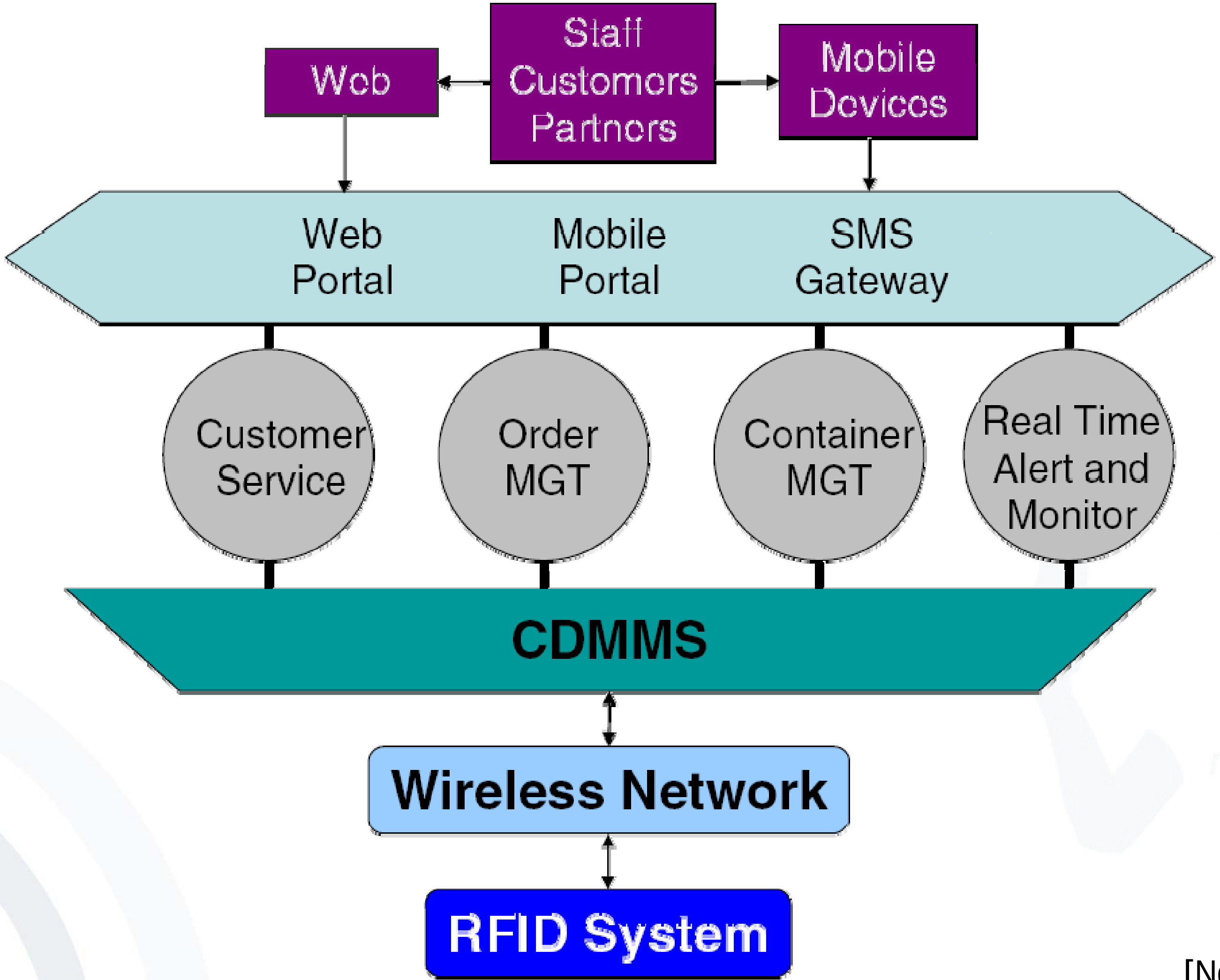
With the current system infrastructure, the container depot is facing several problems:

- Limitations of Walkie-Talkie communication system used
- Container misplacement
- Ownership of containers not clear
- Dependence on experienced staff
- Inefficiency in the search for containers

➲ Can the RFID-based system design solve these problems?

[Ngai et al. 2007]

System Architecture



[Ngai et al. 2007]

Benefits Identified by the Case Study

- Increased container utilization (due to automated management and localization of containers)
- Increased operational efficiency (technology-controlled support of previously labor-intensive processes)
- Better quality control and customer services (e.g. enhanced data analyses, real-time tracking and alerting services)

[www.container-sys.com]

- Reduced return and pickup lead-times, and costs (reduced waiting times of trucks increases the capability of the existing infrastructure)
- Improved service quality and profitability (real-time status reports available, frequently and less frequently used container types, i.e. infrastructural bottle-necks can be identified)

[Ngai et al. 2007]

Some Challenges identified by the Case Study

- Material issues: metal containers can reflect radio waves.
- Electromagnetic interferences: Multiple sources of electromagnetic interference
- Business process issues: Implementing an RFID-based system can demand for fundamental redesign of business processes.

- Security issues: RFID usage could cause omnipresent surveillance

[Ngai et al. 2007]

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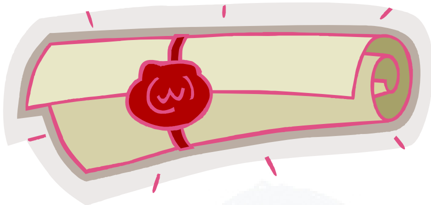
Example 2: Secure M-Commerce Transactions

- For conducting secure mobile transactions, an end-to-end authenticated and private channel is required.
- Corresponding protocols (e.g. HTTPS) are based on Identity Certificates, whose validity needs to be checked.



- "The Online Certificate Status Protocol (OCSP) enables applications to determine the (revocation) state of an identified certificate." [Myers et al. 1999]
- "OCSP client issues a status request to an OCSP responder and suspends acceptance of the certificate in question until the responder provides a response." [Myers et al. 1999]

An Infrastructure Design for Certificate Validation in M-Commerce Transactions

- Online certificate-proofs using OCSP consume much processing capacity and bandwidth, both being limited resources in mobile communication scenarios.
- H-OCSP is a modified OCSP protocol concept addressing these issues.
- The idea behind H-OCSP is that validation functions could be delegated to a broker in order to reduce resource utilization in the client.
- Furthermore, mobile clients can benefit from H-OCSP by storing responses of frequently used certificates in their cache.

[Muñoz et al. 2003]

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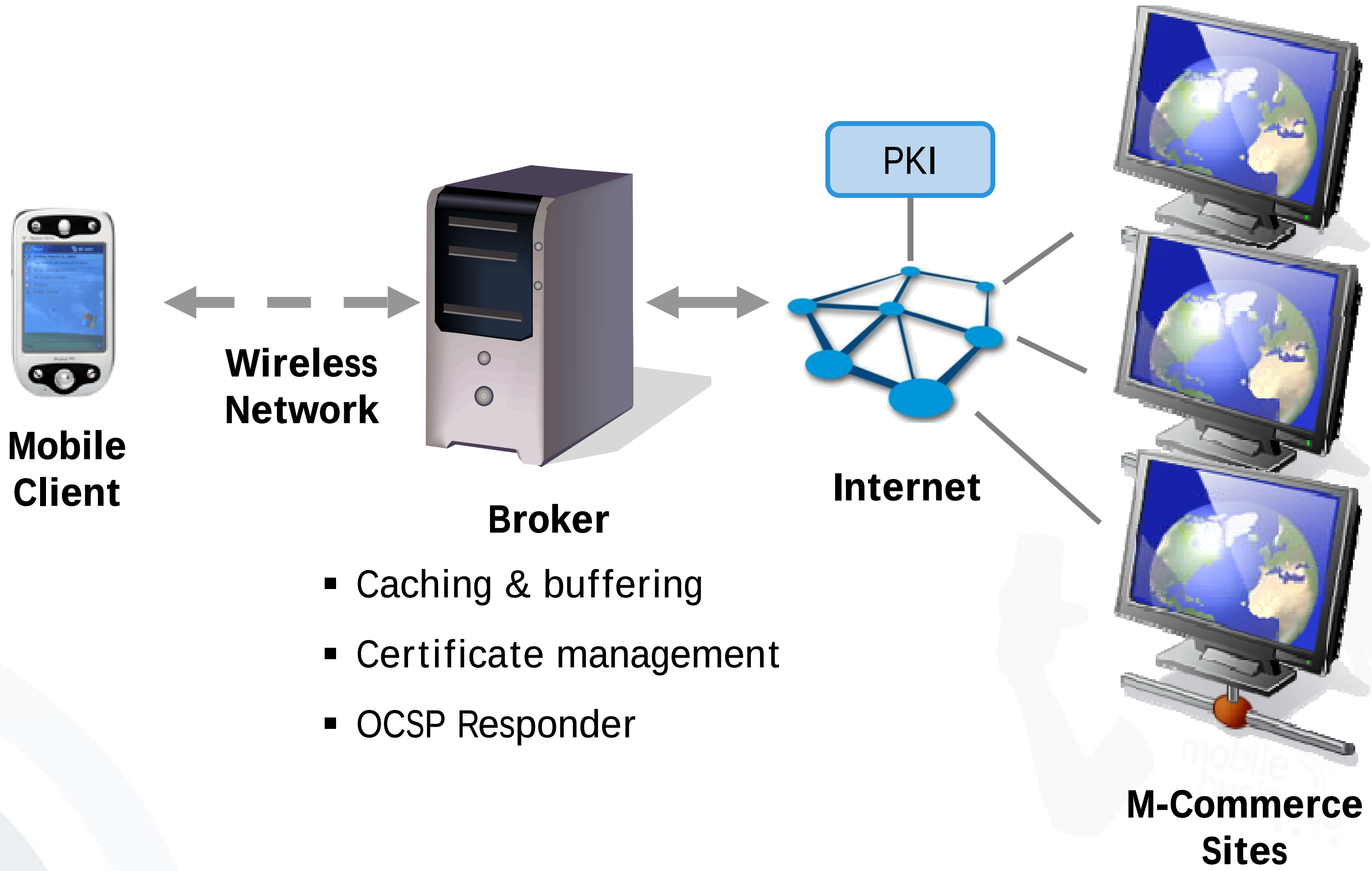
System Architecture



[Based on: Muñoz et al. 2003]

Evaluation Approach: Dynamic Analysis

- The developed H-OCSP protocol is evaluated by conducting a dynamic analysis addressing the two identified bottlenecks of the traditional OCSP protocol (processing capacity utilization and bandwidth consumption)

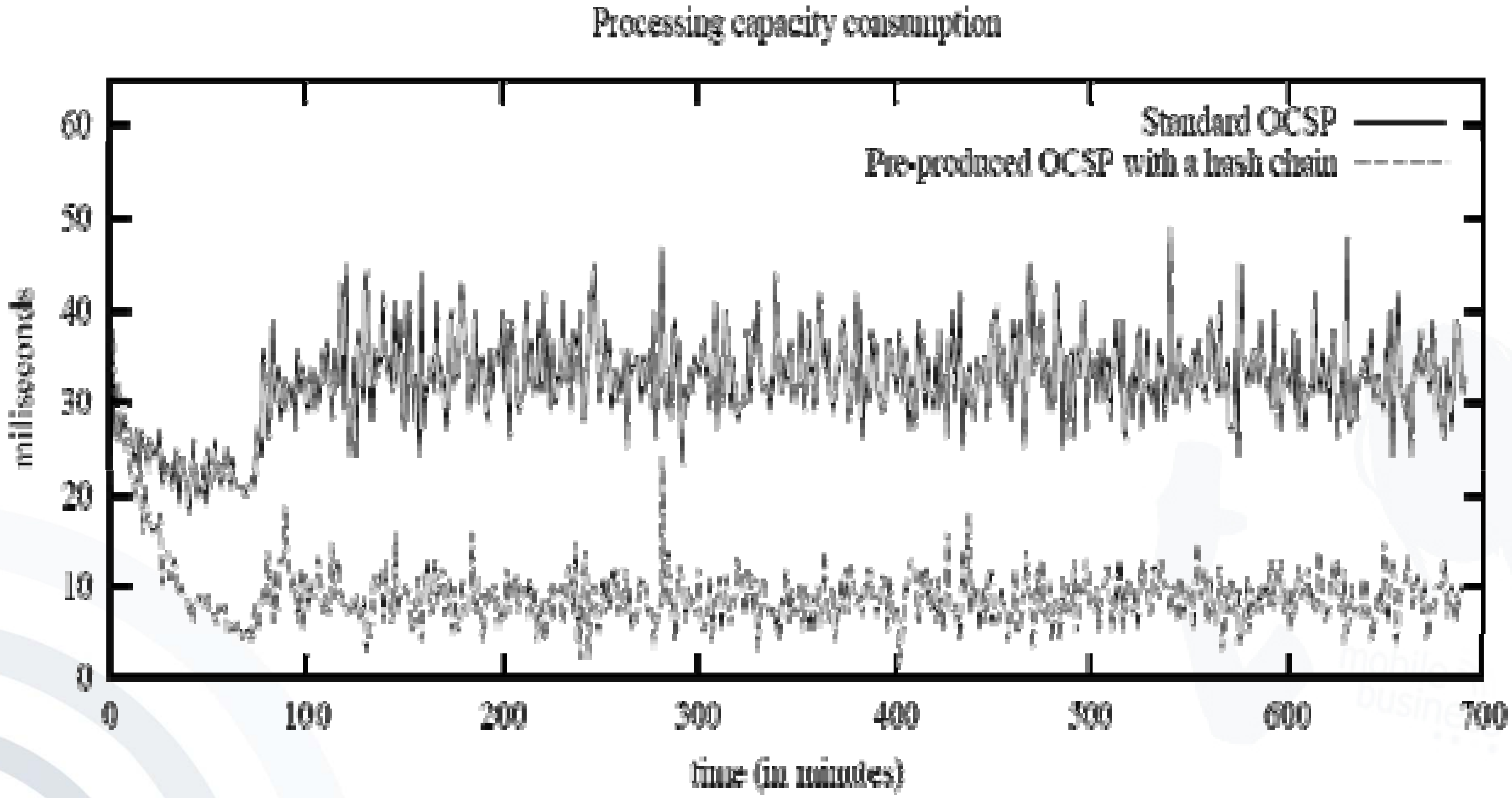
Analytical	Static analysis	Examines structure of artifact for static qualities (e.g. complexity)
	Architecture analysis	Studies how artifact fits into technical IS architecture
	Optimization	Demonstrates inherent optimal properties of artifact or provides optimality bounds on artifact behavior
	Dynamic analysis	Studies artifact in use for dynamic properties (e.g. performance)

- By comparing the performance of standard OCSP with H-OCSP in terms of the bottlenecks identified, the newly developed protocol concept can be evaluated.

[Muñoz et al. 2003]

Dynamic Analysis: Performance Measurement I

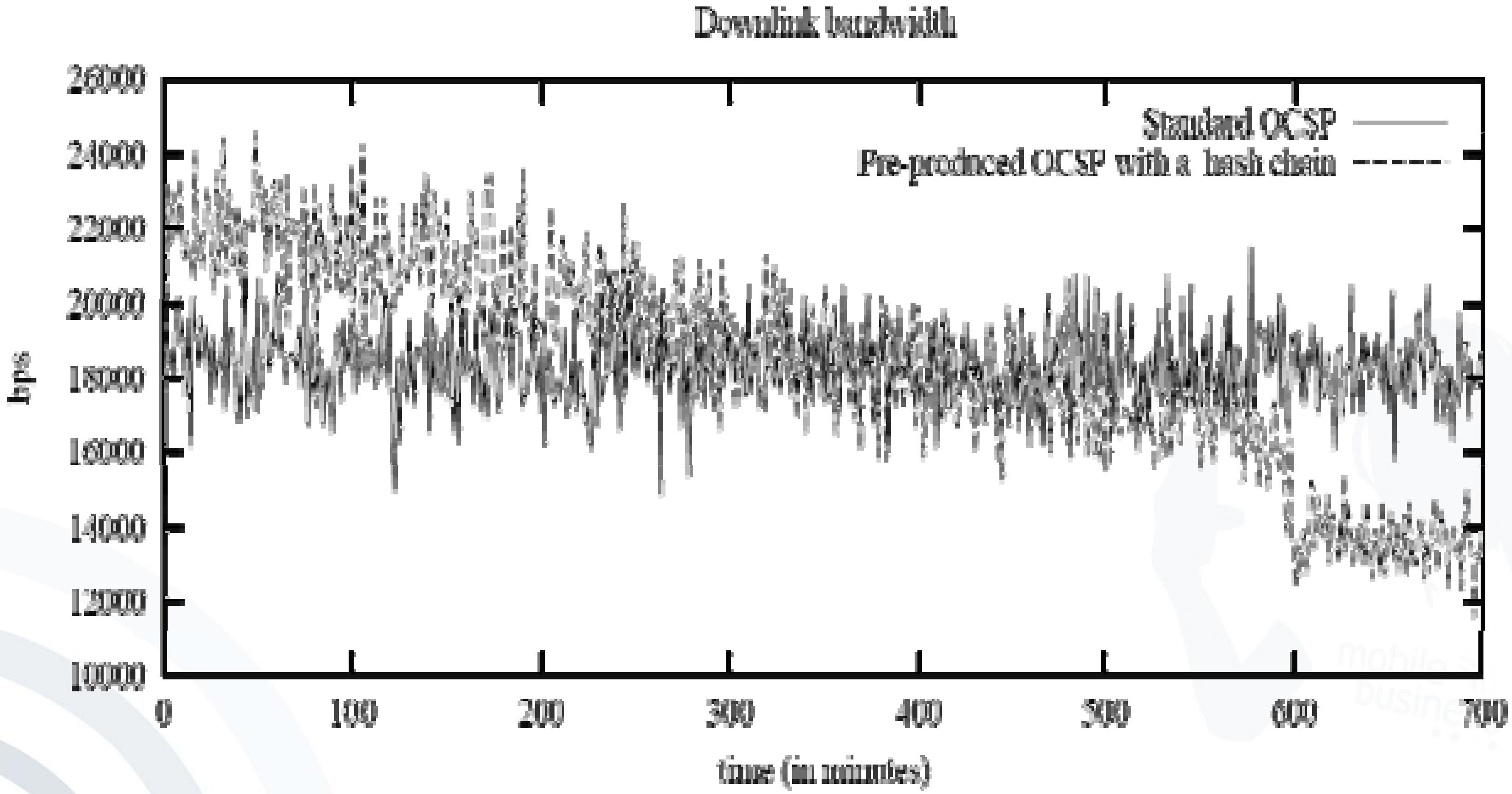
Processing capacity consumption



[Source: Muñoz et al. 2003]

Dynamic Analysis: Performance Measurement II

Down-link bandwidth comparison



[Source: Muñoz et al. 2003]

Conclusion

- The Dynamic Analysis provides insights into performance issues by comparing capabilities of existing approaches with new designs.
- After a short period of time (around 70 minutes) the newly designed H-OCSP protocol consumes approx. five times less computational load at the responder compared to the original OCSP protocol.
- The down-link bandwidth utilization is decreasing significantly when the client's cache is fully working and the more frequently asked certificates are requested.

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Example 3: *iTriage* – A Prototypical eHealth Application Design

- *iTriage* is a prototypical eHealth application design that assists nurses to determine the level of urgency of medical attention and decisions (=triage).
- The nurses are guided during their decision-making by *iTrage.*
- They select categories that best classify the patient's need for medical attention.

[Padmanabhan et al. 2006]

Evaluation Approach: Controlled Experiment

- The *iTriage* application design was explored by conducting a laboratory study (experiment within a controlled environment).

Experimental	Controlled experiment	Studies artifact in controlled environment for qualities (e.g. usability)
	Simulation	Executes artifact with artificial or historical data

- An evaluation framework was developed in order to assess the „decision impact" of the application design.
- The „decision impact" can be evaluated by comparing decision results of two different groups (nurses that were using *iTriage* (PDA Group) and a second group which doesn't (Paper Group)).

➲ Controlled experiment

One Evaluation Criteria

- The mean accuracy of triage outcomes were then compared for the two user groups (PDA group vs. paper group).

	PDA Group	Paper Group
Mean accuracy of triage outcomes	67%	53%

[Source: Padmanabhan et al. 2006]

Further Evaluations

Qualitative user feedback can provide further information how to enhance an application design, such as:

- Application features participants liked best
- Application features participants disliked most
- Missing application features participants wanted most

Conclusion

Controlled experiments can provide valuable information and knowledge to the management, users, and system designers, such as:

- Investigation of potential risks involved
- Understanding of the application usage and the range of applicability
- Training of system users
- Evaluation of necessary change requirements

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Example 4: *MoFiNS* - A Prototypical eFinance Application Design

- *MoFiNS* is a prototypical mobile financial notification system.
- The prototypical system design identifies relevant market events and proactively notifies investors via a mobile push message.
- Investors are enabled to react promptly to critical market events.

[Muntermann 2005]

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Evaluation Approach: Customers' Value Simulation

- The evaluation of *MoFINS* is based on a simulation of the value provided to customers ' using the system.

Experimental	Controlled experiment	Studies artifact in controlled environment for qualities (e.g. usability)
	Simulation	Executes artifact with artificial or historical data

- This value is measured via defined metrics which define the potential trading profits that can be realized by investors due to a decreased reaction time.

[Muntermann and Janssen 2005]

Evaluation Criteria Definition

$$r_{di} = \underbrace{-x_i \cdot \frac{p_{it_c} - p_{it_d}}{p_{it_c}}}_{return\ of\ sold\ stocks} + \underbrace{x_i \cdot \frac{p_{it_c} - p_{it_d}}{p_{it_c}}}_{return\ of\ bought\ stocks} \qquad y_d = \sum_{i=1}^{I} r_{di} - c_i$$

with $d = \{0,15,30,45,60,90,120\}$

r_{di} = realizable return with index *i* and *d*
y_d = realizable yield with index *d*
x_i = trading volume (in €) index *i*
p_{it_c} = closing price of stock with index *i*
p_{it_d} = first available price of stock *i*, *d* minutes following the event date
c_i = costs for trading of stocks with index *i*
d = reaction delay of the investor
i = index of affected stock

[Muntermann and Janssen 2005]

Historical Simulation Approach

- Using a number of historical events (n=265) and stock price reactions observed, a simulation approach can assess potential trading profits that can be realized due to a decreased reaction time *d*.

- y_d is calculated for all events, for different trading volumes, and for different reaction delay levels $d = \{0,15,30,45,60,90,120\}$ minutes.

[Muntermann and Janssen 2005]

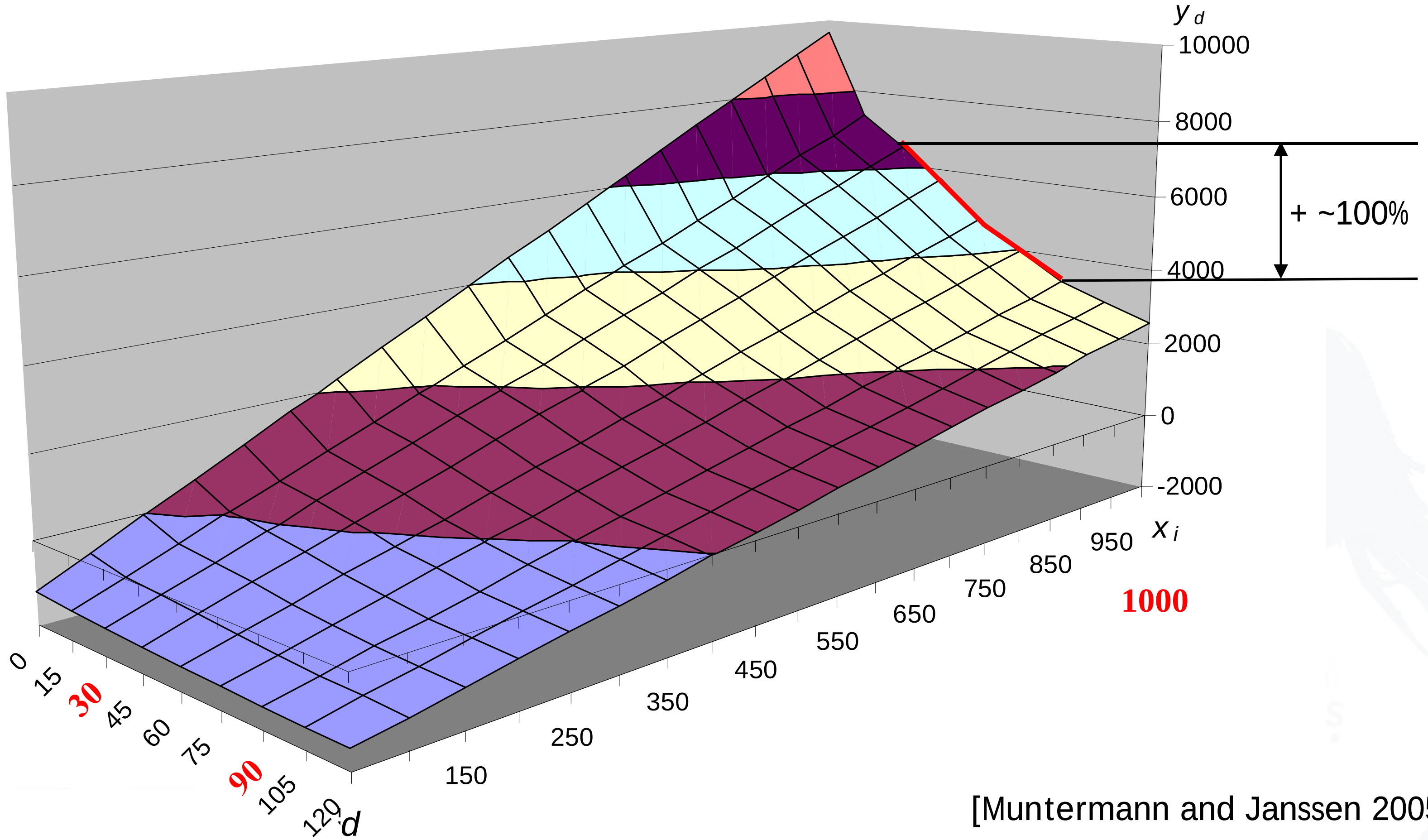
Simulation Results

Simulated Realizable Yields in € for d ={0, 15, 30, 45, 60, 90, 120} and x_i={50, 100, ..., 1000} per Year							
d [min]	*d* [min] *0*	*15*	*30*	*45*	*60*	*90*	*120*
x_i [€] *50*	-1177.87	-1297.17	-1336.25	-1376.90	-1425.99	-1497.46	-1532.94
100	-606.73	-845.35	-923.49	-1004.79	-1102.98	-1245.91	-1316.88
150	-35.60	-393.52	-510.74	-632.69	-779.96	-994.37	-1100.83
200	535.53	58.30	-97.98	-260.59	-456.95	-742.83	-884.77
250	1106.66	510.13	314.77	111.51	-133.94	-491.29	-668.71
300	1677.80	961.95	727.52	483.62	189.07	-239.74	-452.65
350	2248.93	1413.78	1140.28	855.72	512.09	11.80	-236.60
400	2820.06	1865.60	1553.03	1227.82	835.10	263.34	-20.54
450	3391.19	2317.43	1965.79	1599.92	1158.11	514.89	195.52
500	3962.33	2769.25	2378.54	1972.03	1481.12	766.43	411.58
550	4533.46	3221.08	2791.29	2344.13	1804.14	1017.97	627.63
600	5104.59	3672.90	3204.05	2716.23	2127.15	1269.51	843.69
650	5675.72	4124.73	3616.80	3088.33	2450.16	1521.06	1059.75
700	6246.86	4576.55	4029.56	3460.44	2773.17	1772.60	1275.81
750	6817.99	5028.38	4442.31	3832.54	3096.19	2024.14	1491.86
800	7389.12	5480.20	4855.06	4204.64	3419.20	2275.69	1707.92
850	7960.25	5932.03	5267.82	4576.74	3742.21	2527.23	1923.98
900	8531.39	6383.85	5680.57	4948.85	4065.22	2778.77	2140.04
950	9102.52	6835.68	6093.32	5320.95	4388.24	3030.31	2356.09
1000	9673.65	7287.50	6506.08	5693.05	4711.25	3281.86	2572.15

[Muntermann and Janssen 2005]

Simulation Results (Graphical Illustration)

Realizable Yields for *d* = {0,15,...,120} and x_i = {50,100,...,1000}*



[Muntermann and Janssen 2005]

*) trading costs taken from comdirect Bank AG

Conclusion

- Simulation-based experimental evaluations can simulate the impact of the application usage on customer benefits.
- Appropriate evaluation metrics need to be defined.
- Historical or artificial data is needed for running a simulation.
- As the evaluation approach addresses services that are not available yet, this ex-ante evaluation addresses the potential value of a corresponding IT investment.

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Summary & Conclusion

- Different application or service designs demand for a selection of appropriate evaluation methods.
- Appropriate evaluation criteria need to be identified.
- Most evaluations are based on pre-defined evaluation metrics.
- The selection of evaluation criteria and metrics depends on datasets available or observable.

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