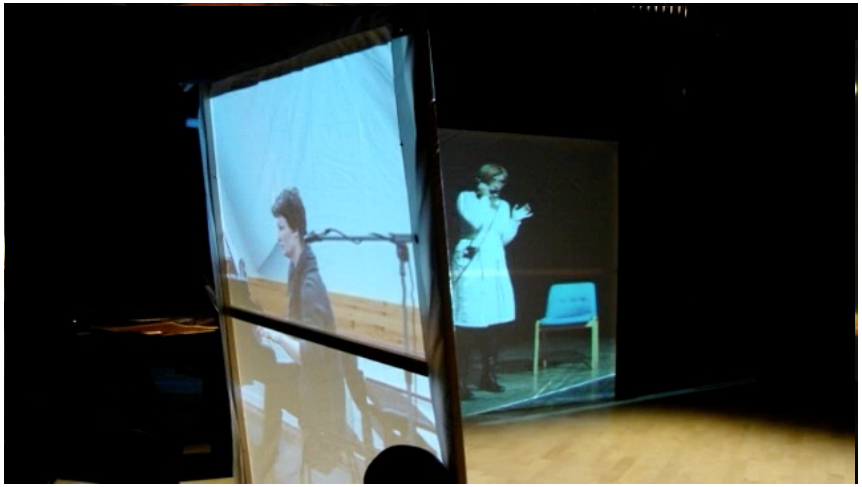
IN5060

Quantitative Performance Analysis

autumn course

UiO : University of Oslo

What is performance?

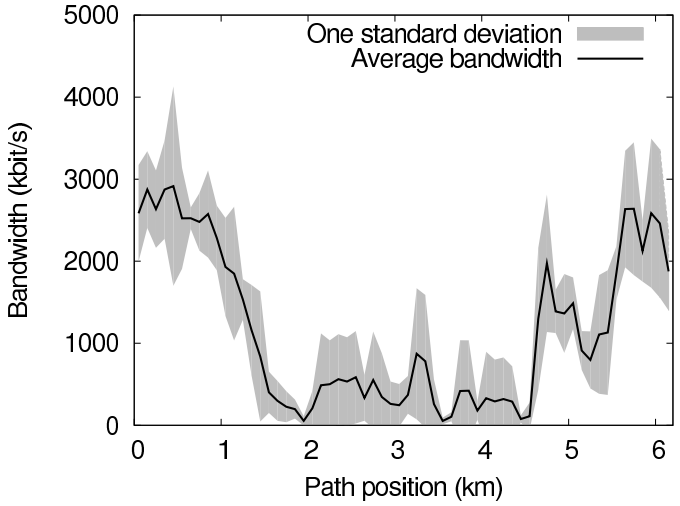


Stage performance

World Opera Production – Dec 2011 @ Tromsø

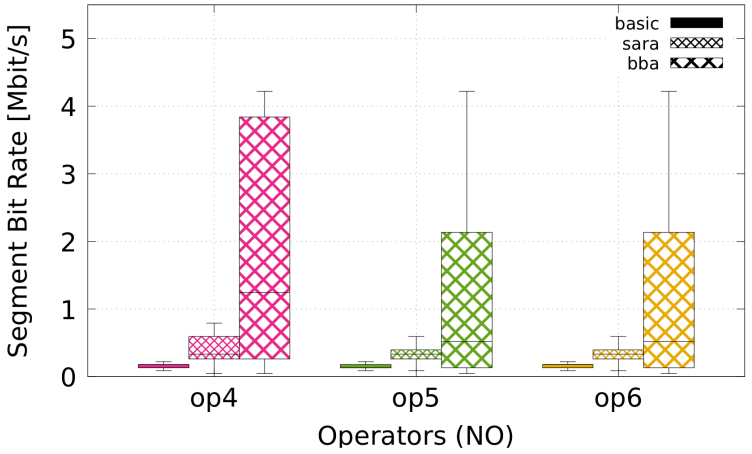
Stage performance

Third Life Project@WUK – Oct 2015 @ Vienna



Download performance by position

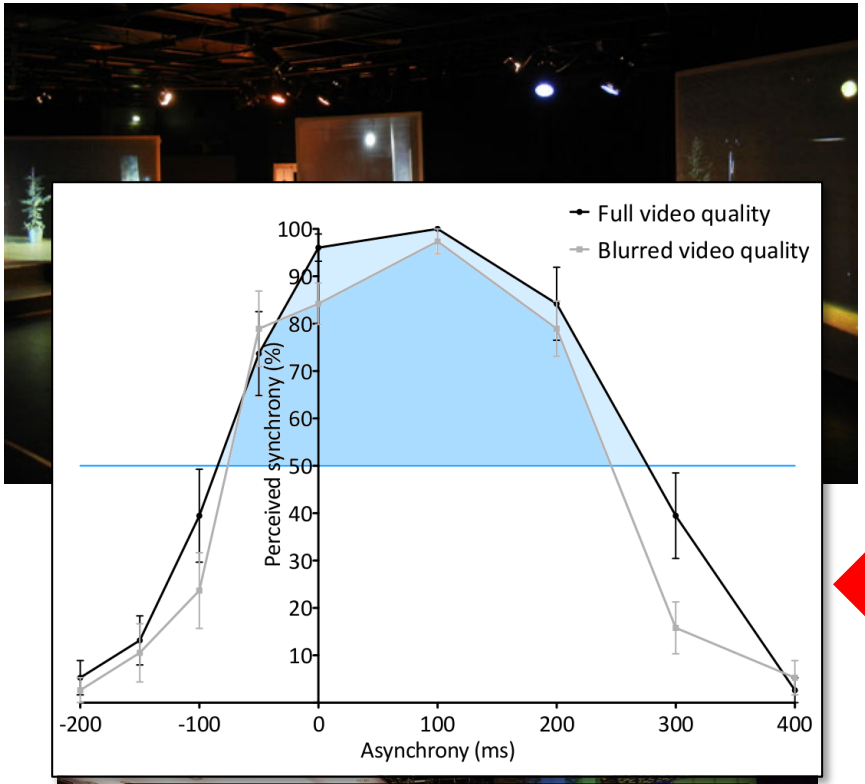
HTTP Adaptive Streaming measured on Bygdøy Ferry, 2011



Download performance by operator & algorithm

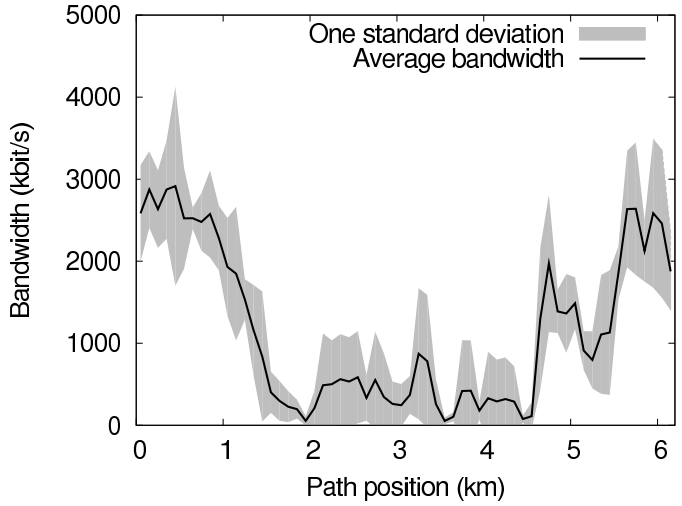
HTTP Adaptive Streaming, MONROE nodes, 2018

What is performance?

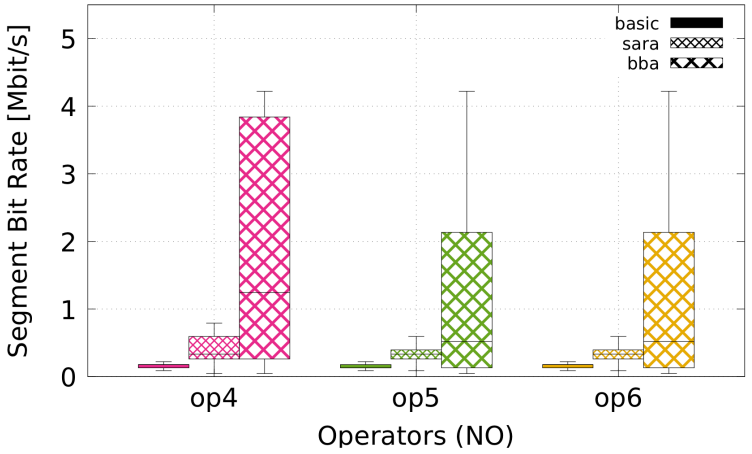


Users' perception (Quality of Experience)
Asynchrony between audio and video, 2015

Stage performance
Third Life Project@WUK – Oct 2015 @ Vienna



Download performance by position
HTTP Adaptive Streaming measured on Bygdøy Ferry, 2011



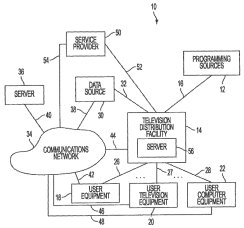
Download performance by operator & algorithm
HTTP Adaptive Streaming, MONROE nodes, 2018

Quantitative Performance Analysis

Engineers and researchers solve quantifiable challenges

Idea

Simulation Study



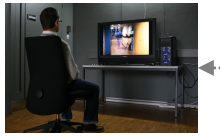
Prototype

Product

NETFLIX

amazonPrime

Deployment



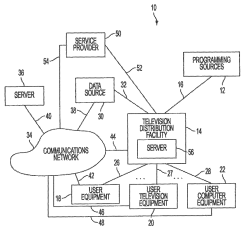
Feedback

Quantitative Performance Analysis

Engineers and researchers solve quantifiable challenges

Idea

Simulation Study



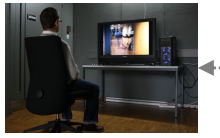
Prototype

Product

NETFLIX

amazon Prime

Deployment



Feedback

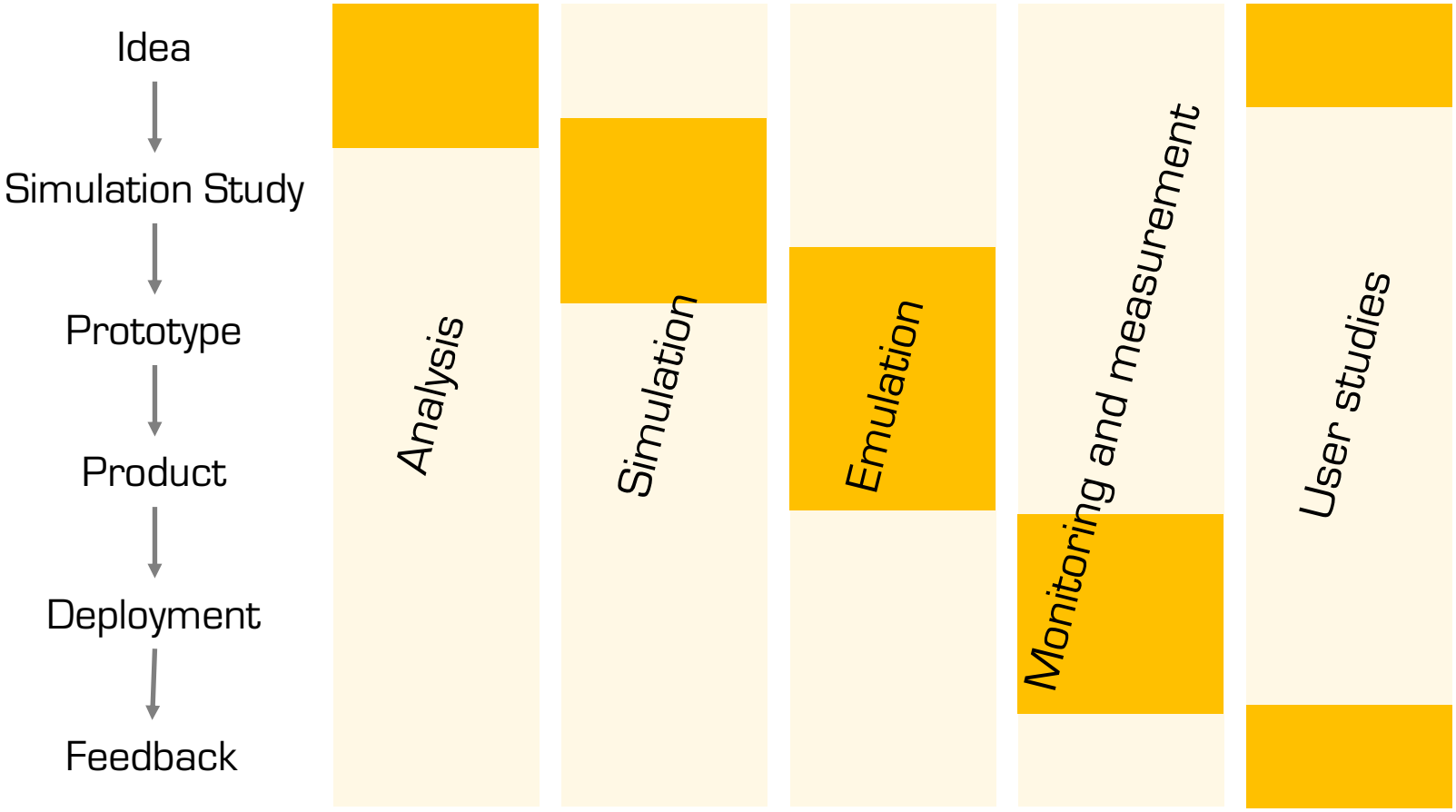
Each step requires a performance assessment

- argue for feasibility
- demonstrate practicality
- study in a context
- measure in the real world
- assess value / success

Performance Evaluation

Quantitative Performance Analysis

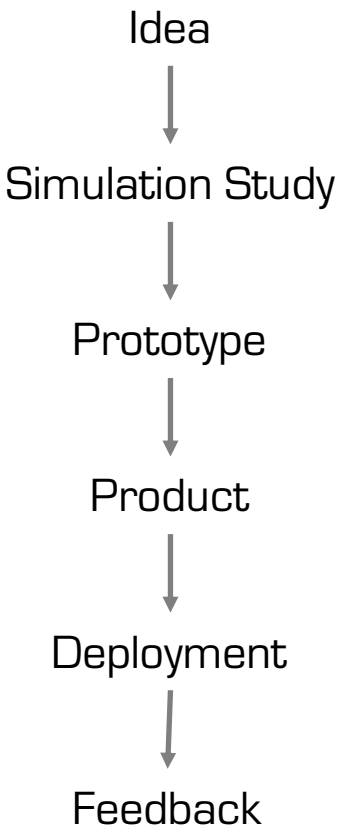
Engineers and researchers solve quantifiable challenges



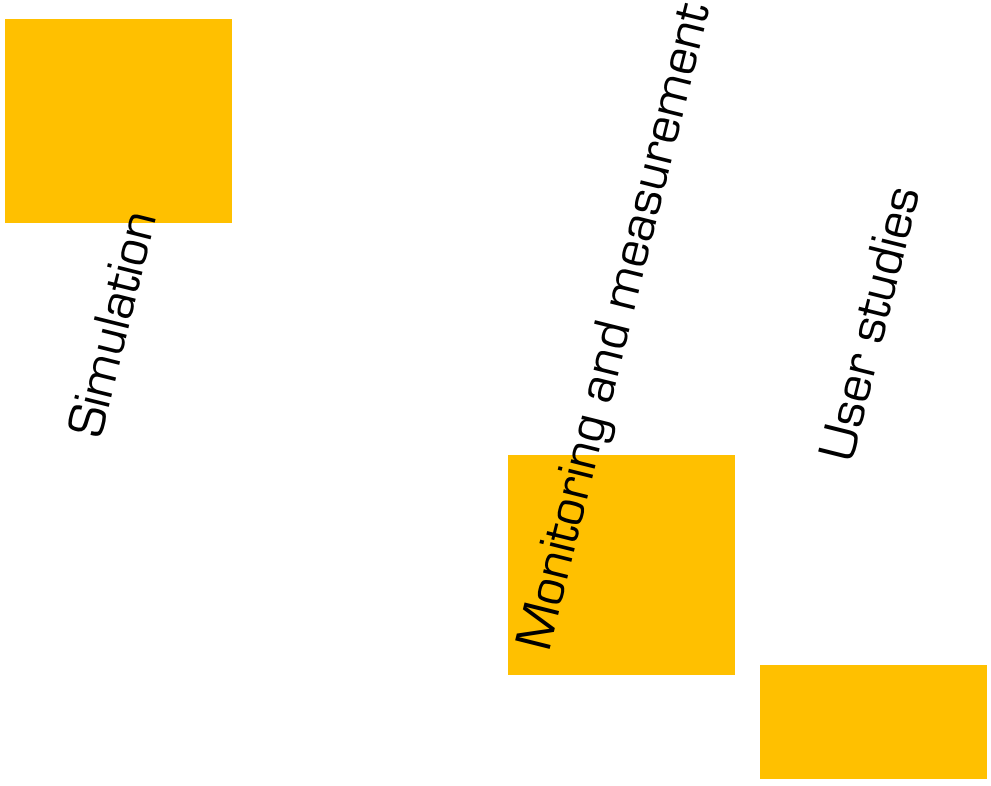
Performance Evaluation

Quantitative Performance Analysis

Engineers and researchers solve quantifiable challenges



IN5060: experience 3 examples



Performance Evaluation

Quantitative Performance Analysis

Designing and conducting studies

- pre-considerations
- avoiding bias
- measurement points and methods
- data reduction
- drawing conclusions

Presentation and reporting

- formulating a message
- selecting relevant factors
- extracting and interpreting statistics
- dimension reduction
- selecting presentation modes

Specific considerations

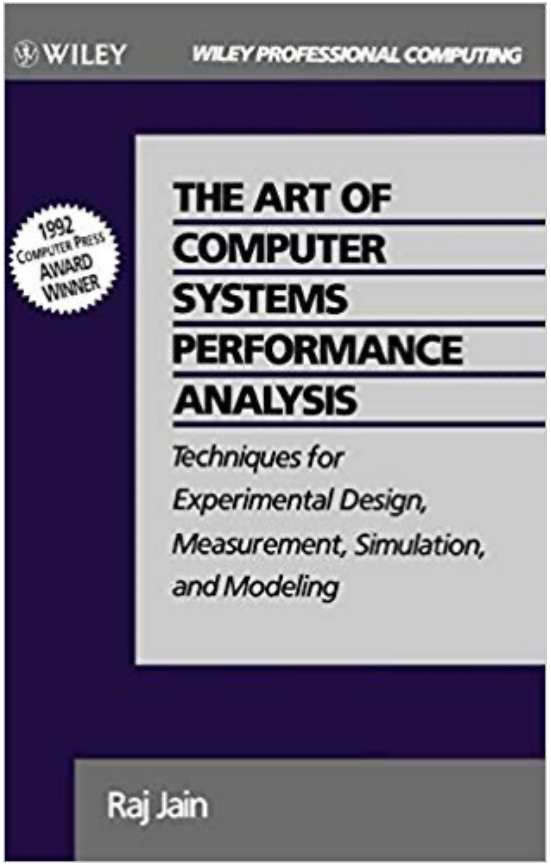
- simulation
- monitoring and measurement
- user studies

Quantitative Performance Analysis

- This course is meant to provide you with a taste of the skills needed to become a good system analyst.
- It will provide you with hands-on experience in system evaluation
- It will (to some extent)
  - confront you with the tradeoffs encountered when analysing real systems
  - confront you with the error sources and red herrings encountered when analysing real systems

Quantitative Performance Analysis

- The course is based on the book "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling" by Raj Jain



- Reading the book is not mandatory for the course or even necessary to complete, but if you have a chance to read it in full, **do so!**

System performance analysis

Who is interested in system performance analysis?

- The HW designer (company) wants to show that their system is The Best and Greatest system of All Time
- A software provider wants to show that their application is superior to the competition
- The researcher wants to publish her papers, and needs to convince the reviewers that their research improves on the state- of-the-art
- The system administrator or capacity planner needs to choose the system that is best suited for their purpose
- The enthusiast who wants to see if the newest rage from *<insert favourite multinational corporation>* is real, or fake news

System performance analysis

- How do they achieve this?
  - By providing a comparison between their own system and “the competition”
  - The results need to be *(or appear)* convincing to the target audience
  - This comparison is made through proper system performance analysis

- The techniques of models, simulations and measurement are all useful for solving performance problems
  - IN5060 will focus on experimental design, simulation, measurement and analysis
  - For modelling try for instance: MAT-INF3100 - Linear Optimisation

Theory and practice

- Theory / models will provide us with candidates for system optimisations
- Deploying them in reality may in many cases lead to unforeseen results
  - Hardware differences
  - Non-deterministic systems
  - Unexpected workloads
- Key techniques needed
  - Mathematical analysis
  - Simulation
  - Emulation
  - Measurement
  - User studies
  - Measurement techniques (monitors)
  - Data analysis (statistics and presentation)
  - Experiment design

Quantitative Performance Analysis

Key skills of performance analysts

Key skills needed – evaluation techniques

To select appropriate evaluation techniques, performance metrics and workloads for a system

- You must choose which metrics to use for the evaluation
- You must choose which workloads would be representative

What metrics would you choose to compare:

- Two solid state disk (SSD) drives?
- Two adaptive video streaming algorithms?
- Two IaaS Clouds?

Key skills needed – measurements

Conduct performance measurements correctly

- You must choose how to apply workloads to the system
- You must choose how to measure (monitor) the system

Which type of monitor (or "probe", hardware or software) would be suitable for measuring each of the following:

- Number of instructions executed by a processor?
- Context switch overhead on a multi-user system?
- Response time of packets on a network?

Key skills needed – proper statistical techniques

Use proper statistical techniques to compare several alternatives

- Whenever there are non-deterministic elements in a system, there will be variations in the observed results
- You need to choose from the plethora of available statistical methods in order to correctly filter and interpret the results

Which link is better?

File Size	Packets lost on Link A	Packets lost on Link B
1000	5	10
1200	7	3
1300	3	0
50	0	1

Key skills needed – do not measure forever

Design measurement and simulation experiments to provide the most information with the least effort

- You must choose the number of parameters to investigate
- You must make sure you can draw statistically viable conclusions

The performance of a system depends on the following factors:

- Garbage Collection Technique used: G1, G2, or none
- Type of workload: editing, computing, or machine learning
- Type of CPU: C1, C2, or C3

How many experiments are needed?

How do you estimate the performance impact of each factor?