Impact of memory technology trends on performance of Web systems

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Characteristics of today's Web

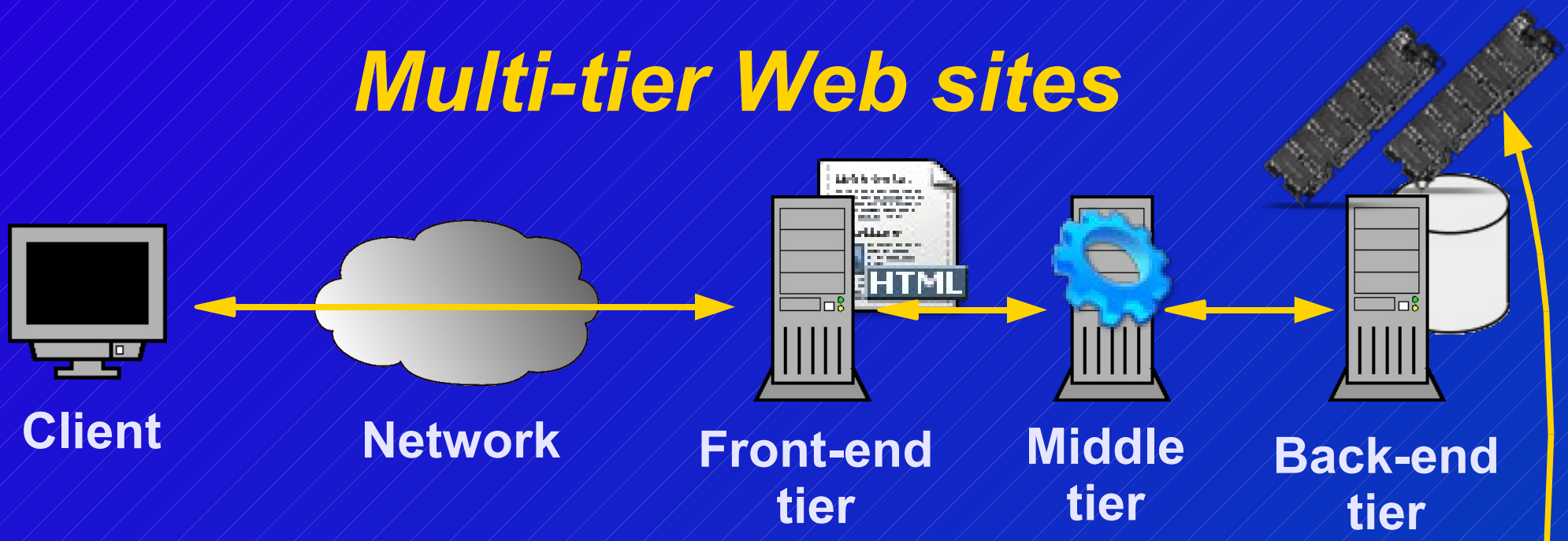
- **Complex Web-based services (dynamic Web content)**
- **Technology trends:**
  - Increasing capacity of network connections
  - Growing amount of available memory (RAM)

Year	Cost [$/Mb]	Typical Amount of RAM
1995	20	128 Mb
2000	2	1 Gb
2005	0,2	8 Gb
2010	0,02	64 Gb

Memory embedded DBs will be common in a near future even for large Web sites

What is the impact of technology trends on Web system performance?

Multi-tier Web sites



- **Front-end tier:** static Web resources, interaction with clients
- **Middle tier:** generation of dynamic Web resources
- **Back-end tier:** data repository (DBMS)

Focus on available memory for the DBMS

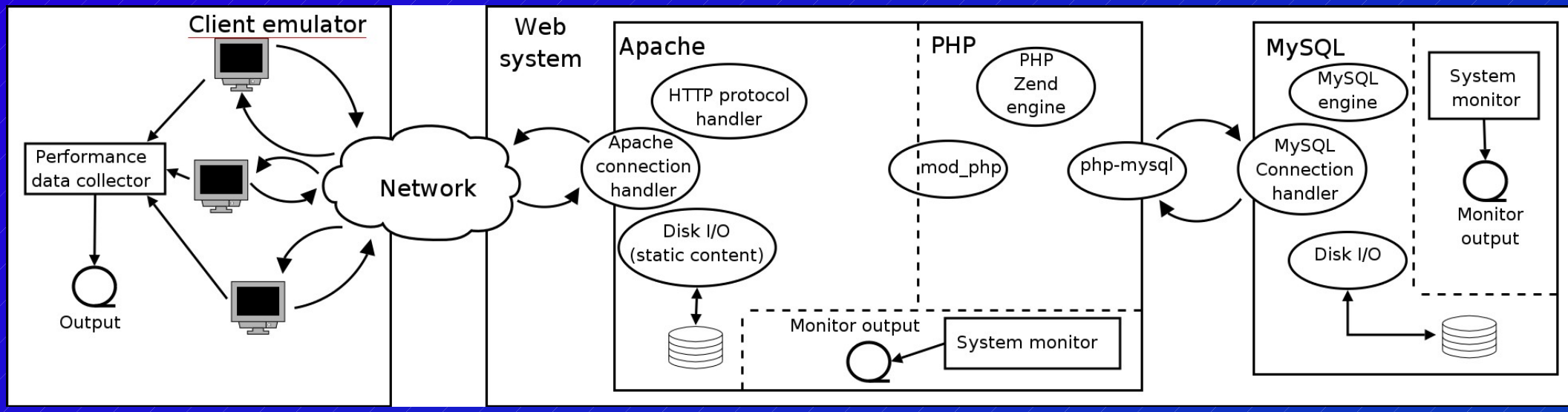
Motivation

- **Technology trends in memory lead to changes:**
  - In the system performance
  - In the bottlenecks limiting the performance

How do bottlenecks change as a function of technology trends? (no previous studies in literature)

- **Bottleneck analysis is essential to plan system upgrade that can improve performance**
- **Need to understand and anticipate the effect of technology trends**
- **This approach can be applied to other Web-based applications and Web services**
  - **Focus on O.S. and server software** (Web, DBMS, application servers)

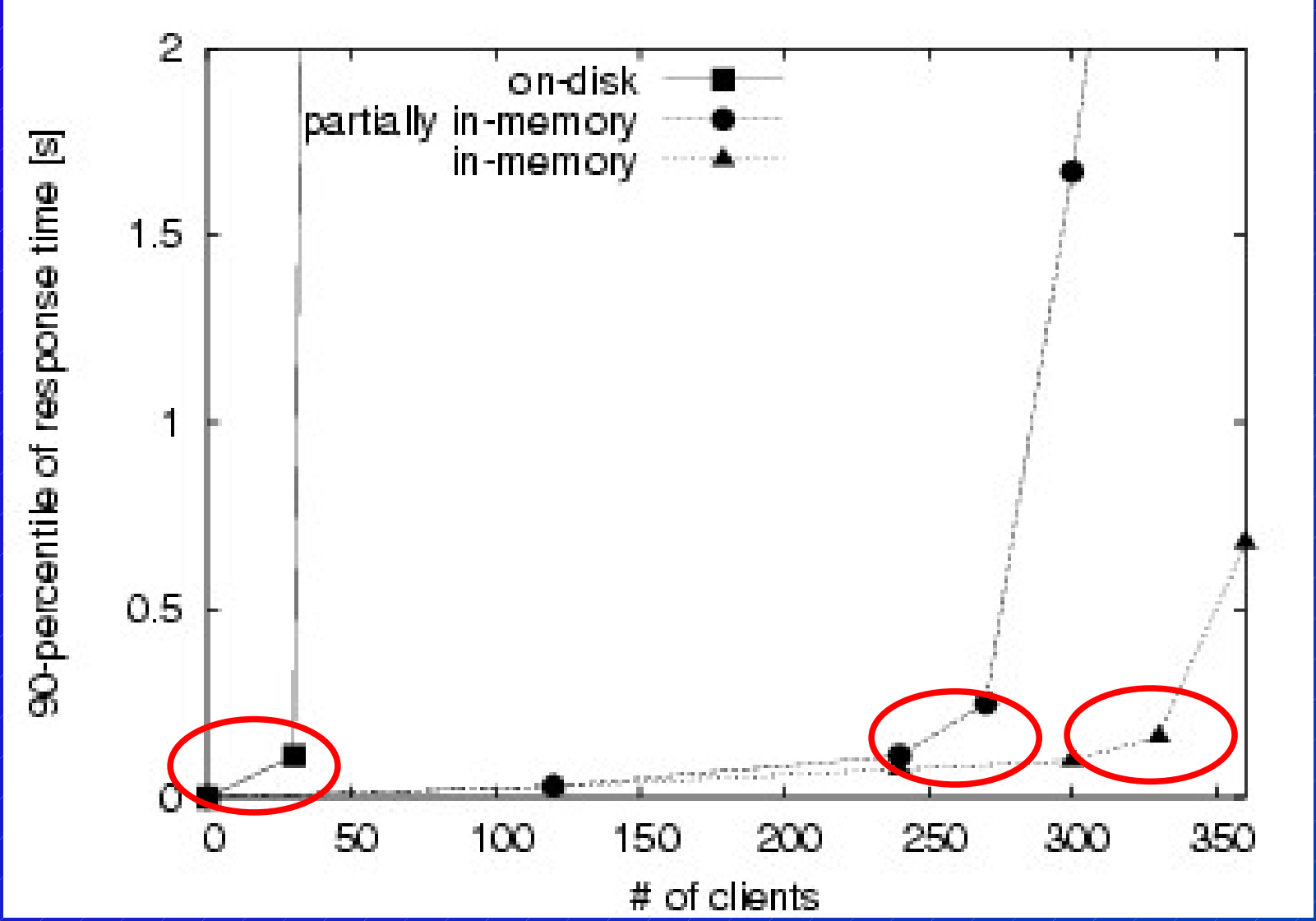
Experimental testbed



- **Dynamic Web site**
  - Apache + PHP +MySQL
  - TPC-W like workload
- **Additional studies with different technologies and workloads** (not shown)
- **Fine-grained performance analysis *(sar, oprofile)***

- **Performance evaluation:**
  - *When does a bottleneck appear?*
  - *What is the bottleneck?*
- **Three memory scenarios:**
  - All in-memory (100% of DB in memory)
  - Partially in-memory (60%)
  - Mostly on-disk (30%)

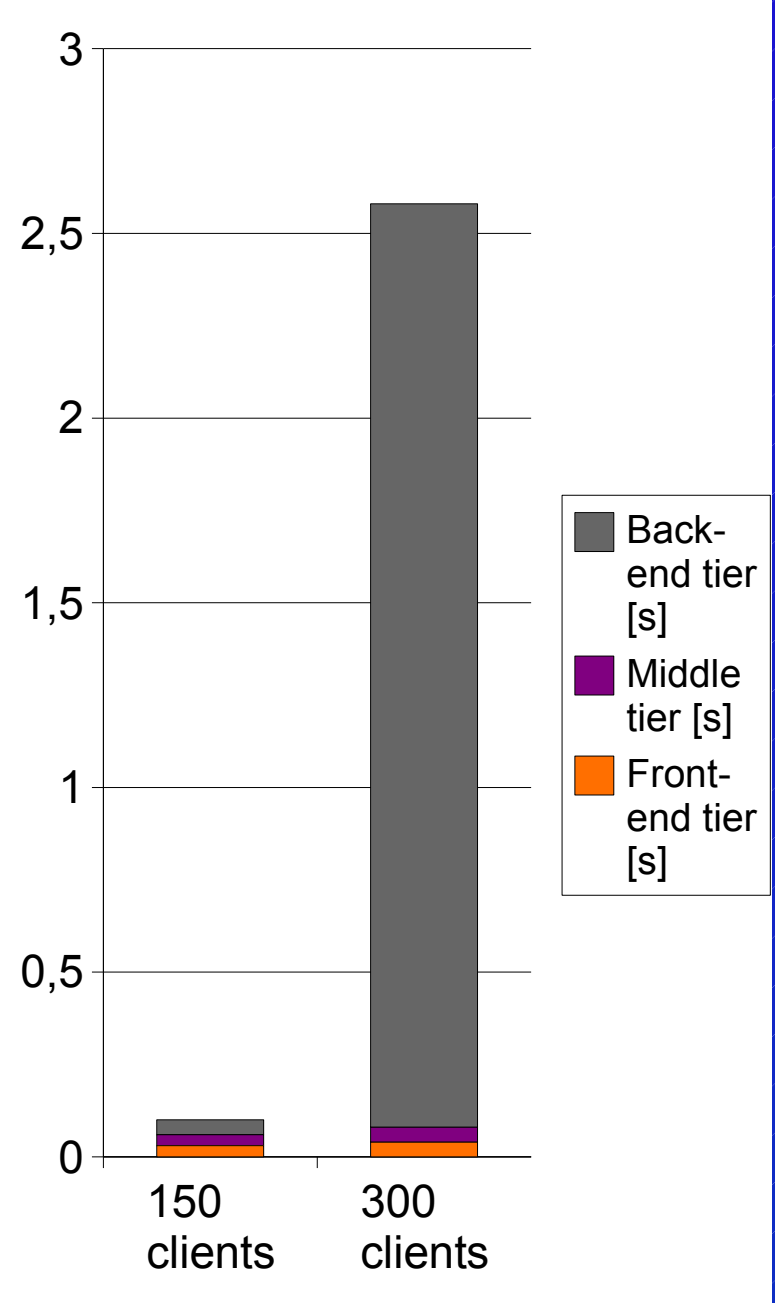
Page response time



Impact of available memory on system capacity

(*When does a bottleneck appear*)

Page response time



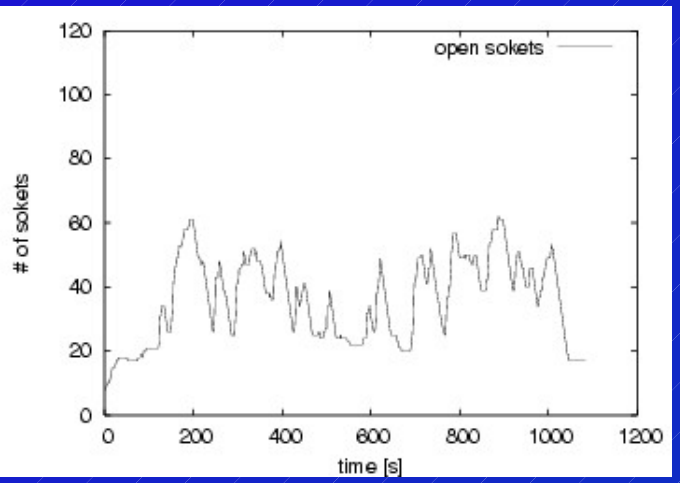
Partially in memory scenario

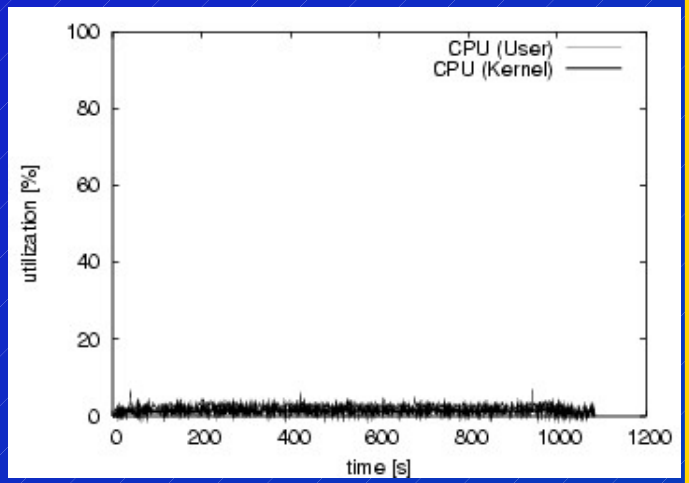
- **Analysis of the contribution to response time by the three tiers**
  - The back-end tier contribution drives the explosion of response time
  - →The bottleneck is on the DBMS
- **Confirmation of the impact of DBMS on performance**
- **This is true for different technologies and scenarios**
  - PHP, J2EE
  - Multiple workload mixes and memory scenarios

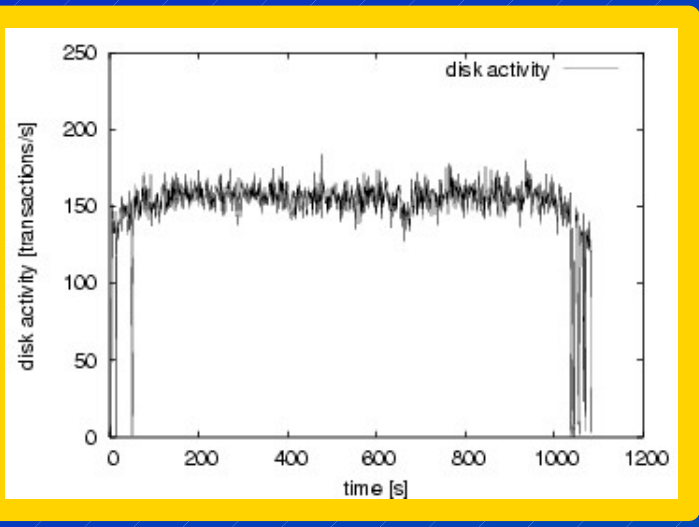
Bottleneck analysis focused on DBMS node

Bottleneck analysis (Mostly on-disk scenario)

- **Bottleneck identification** (*What is the bottleneck*)**:**
  - Low utilization of sockets
  - Negligible utilization of CPU
  - Full utilization of disk

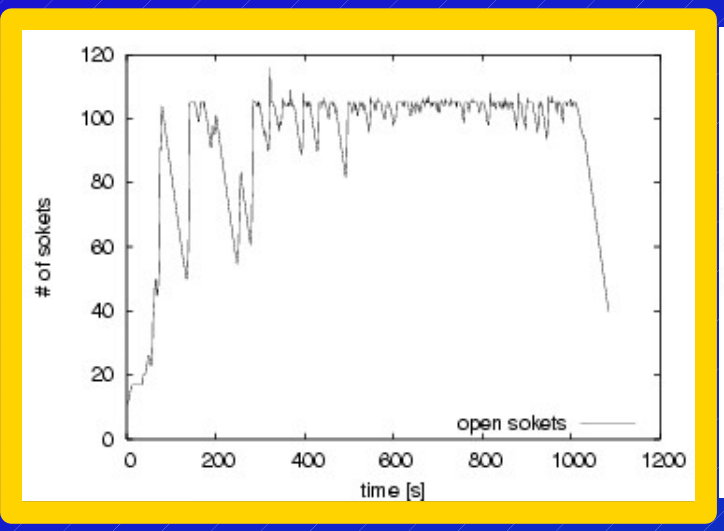


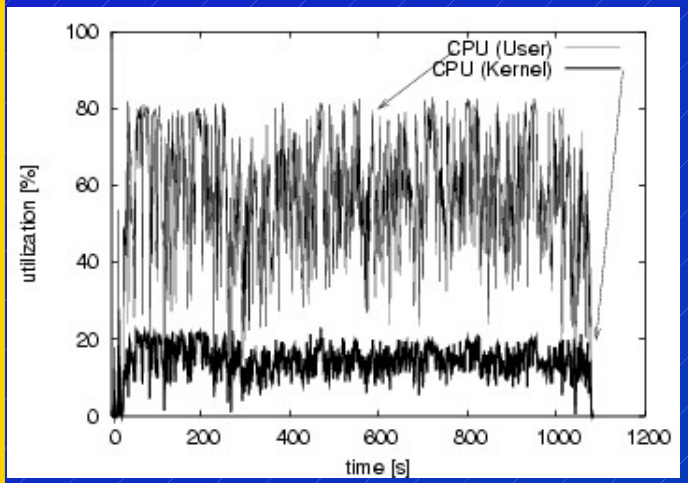


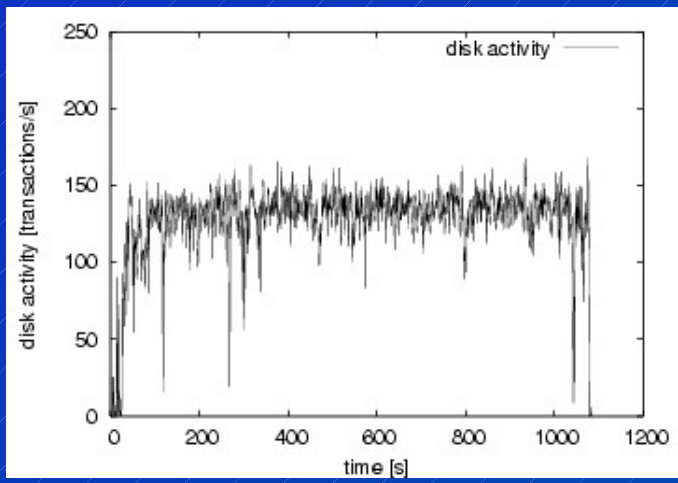


Bottleneck analysis (Partial in-memory scenario)

- **Bottleneck identification** (*What is the bottleneck*)**:**
  - Full utilization of sockets
  - High utilization of CPU
  - High utilization of disk

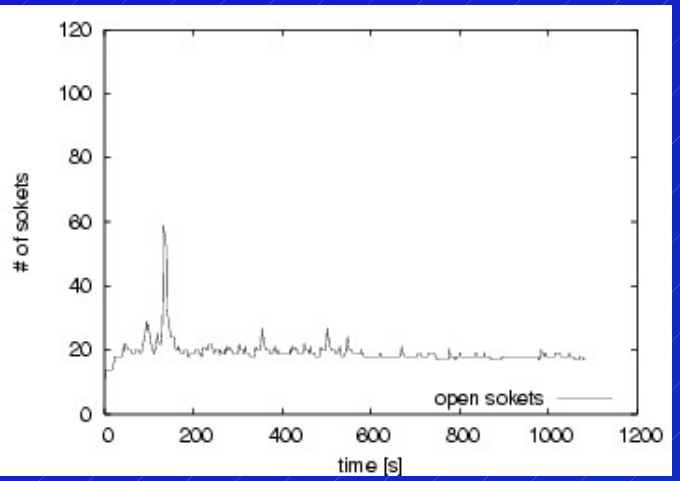


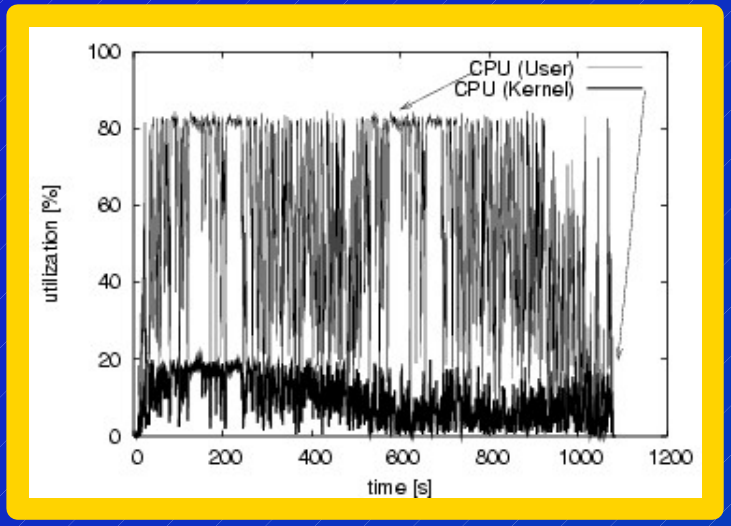


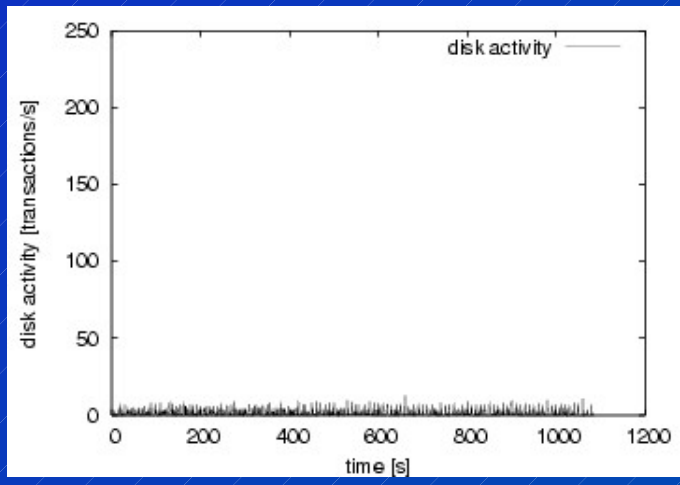


Bottleneck analysis (All in-memory scenario)

- **Bottleneck identification** (*What is the bottleneck*)**:**
  - Low utilization of sockets
  - Full utilization of CPU
  - Negligible utilization of disk





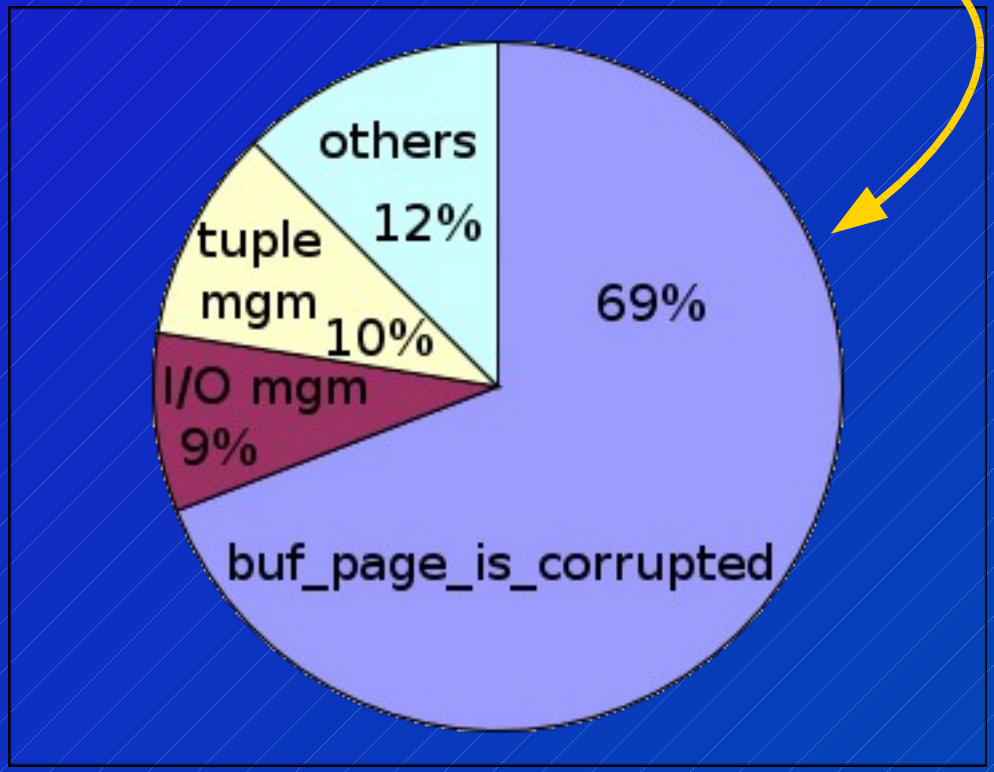


Analysis of results

- **The amount of available RAM on the DBMS has a significant impact on the causes of poor performance**
- **Little memory available → performance is bounded by disk throughput,**
  - Little system level interventions are available (reduced memory → caching effectiveness is reduced)
  - *hardware upgrade is the most effective approach (e.g, RAID systems, memory)*
- **More memory available → socket descriptors limit system performance**
  - high number of parallel requests can be a common situation (e.g., preliminary study on network effects)
  - *should reduce request parallelism (e.g., replication of DBMS nodes, exploit of component-based systems)*

Analysis of results

- **Large amount of memory available → performance is limited by asynchronous I/O (interaction with O.S. disk cache),**
- **Computationally expensive checksumming operations**
  - *Should reduce asynchronous I/O (e.g., query caching)*
- **Message for the future: Interaction between O.S. disk cache and DBMS buffer cache can be inefficient and this can become a major bottleneck**



  - Need for efficient DBMS tailored for memory-embedded DB operations

Future work

- **Evaluation of the impact of network**
  - Increasing capacity of network connections
  - What is the impact of network technology trends on system performance and on system bottlenecks?
- **Study with multiple applications and workloads**
  - Pub/sub systems (e.g., forums, blogs, ...)
  - Web-based Auctions
  - Web services

WEB Lab group homepage

http://weblab.ing.unimo.it/