Part II: Comparing Server Performance

Tim Brecht

www.cs.uwaterloo.ca/~brecht

Outline

- Part I: Background
  - Web Server Example: HTTP/1.1
  - Server Architectures
  - Performance Evaluation
- **Part II: A Flavour of some Current Research**
  - **Performance of Different Server Architectures**
  - Improving Operating System Support for I/O Centric Servers (if time permits)
  - **Possible Avenues for Future Research**

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- **Part II: A Flavour of some Current Research**
  - Performance of Different Server Architectures
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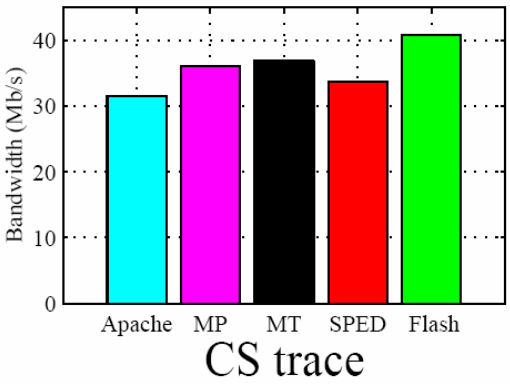
Recall: Some Server Architectures

- Multi-Thread/Process: one thread/process per conn
  - (MT/MP) **Apache, Knot** [apache.org, von Behren et 03]
- Single Process Event Driven [www.zeus.com]
  - (SPED) **Zeus, Original Harvest/Squid** [Wessels, 96]
  - Asymmetric Multi-Process Event Driven
  - (AMPED) **Flash** [Pai et al, 99]
- One copy per CPU [Zeldovich et al, 03]
  - (N-Copy) **? Rock Web Server ?** [accoria.com]
- SYmmetric Multi-Process Event Driven
  - (SYMPED & Shared-SYMPED) **userver** [UW:Brecht et,]
- Hybrid: Staged Event Driven Architecture / Pipelined
  - (SEDA) **Haboob, WatPipe** [Welsh et 01, Pariag et 07]

Some Research History: Threads vs Events

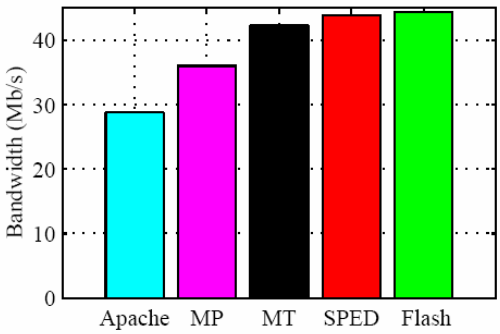
- Duality of OS Structures [Lauer & Needham, 78]
- Why Threads are a Bad Idea [Ousterhout, 96]
- SEDA => Events are Best [Welsh et al, 01]
- Event Driven Programming for Robust Software [Dabek et al, 02]
- Why Events are a Bad Idea [von Behren et al, 03]
- Capriccio: Scalable Threads ... [von Behren et al, 03]
- Multiprocessor Support for Events [Zeldovich et al, 03]

Previous: Flash [from Pai et al, 1999]



CS trace

Previous: Flash [from Pai et al, 1999]



Owlnet trace

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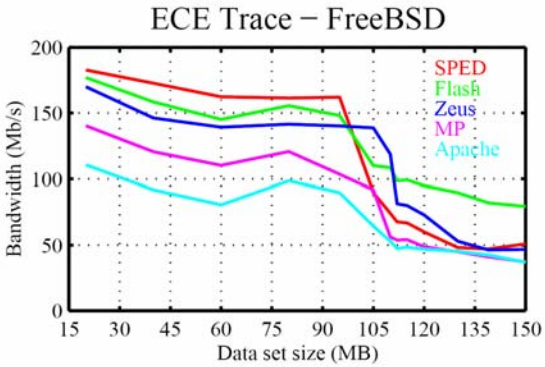
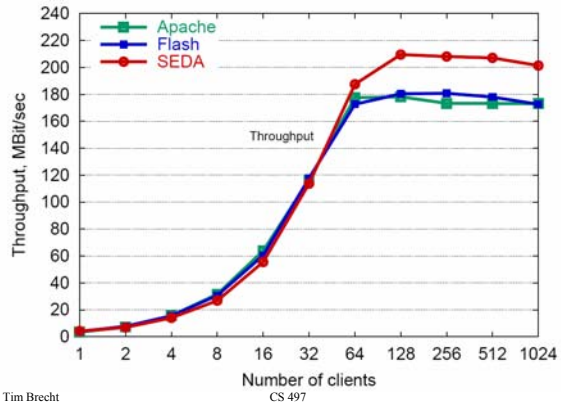


Conclusions

- Amped is best (Flash) [Pai et al. 1999]

Amped ~> SPED > MT/MP > Apache
Flash Flash Flash

Previous: Haboob [from Welsh et al, 2001]



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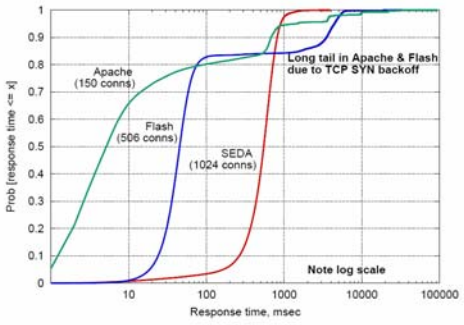

	SEDA	Flash	Apache
Mean RT	547 ms	665 ms	475 ms
Max RT	3.8 sec	37 sec	1.7 minutes

Conclusions

- Amped is best (Flash) [Pai et al. 1999]
- Events are best (SEDA/Haboob) [Welsh et al. 2001]

SEDA > Amped ~> SPED > MT/MP > Apache
Haboob Flash Flash Flash

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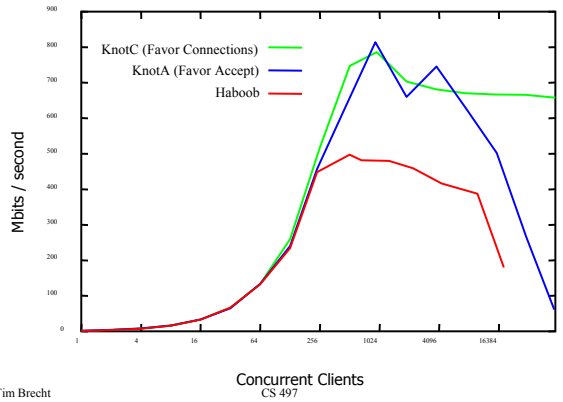

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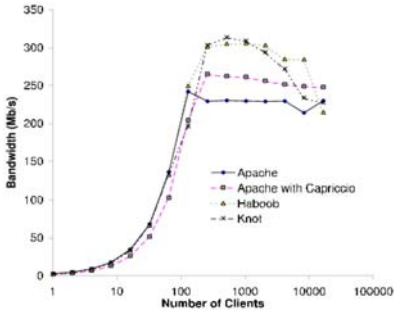

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Knot Haboob Flash Flash Flash
Capricco

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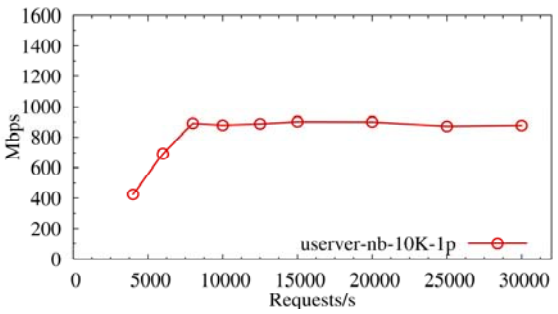
Comparing Performance, EuroSys 2007

- Compare different modern server architectures:
  - Thread-based or Thread-per-Connection or (MT)
    Capriccio / Knot
  - Event-Driven (SYMPED/Shared-SYMPED)
    userver
  - Pipeline-based / Hybrid (Threads and Events)
    WatPipe
    - similar to SEDA/Haboob but in C++; not Java
    - no controllers, no tuning of controllers

Comparing Performance, EuroSys 2007

- Fair comparison, well configured, well tuned servers
  (avoid using Java, as it could be slow)
- Verification: ensure service for all request sizes
  - servers often timing out on large requests
- 3.2 GB file set as in Capriccio and SEDA papers
- **`httperf`** for overload (using client timeouts = 15 s)
- Workload simulates think times
  - forces servers to scale to large numbers of clients (10's of thousands)

SYMPED (userver)



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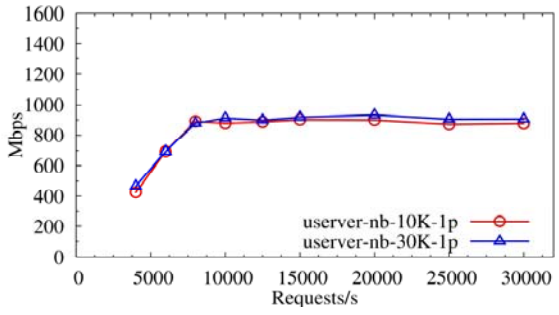

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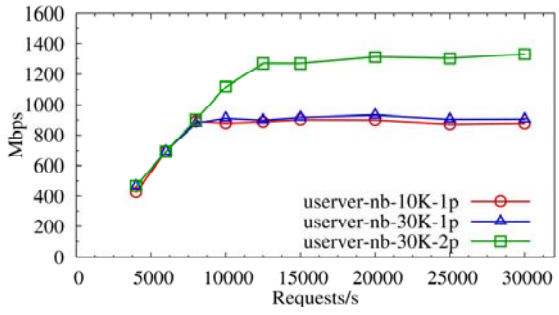

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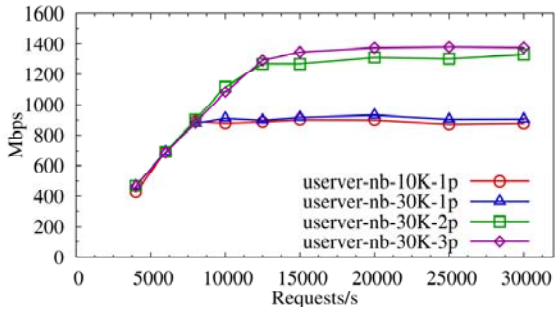

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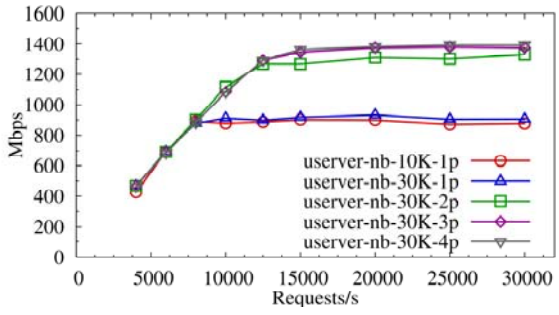
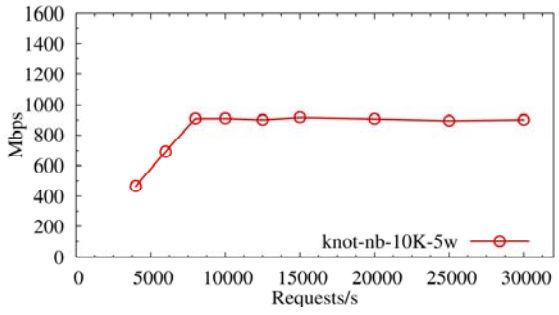


Thread-per-connection (Knot)



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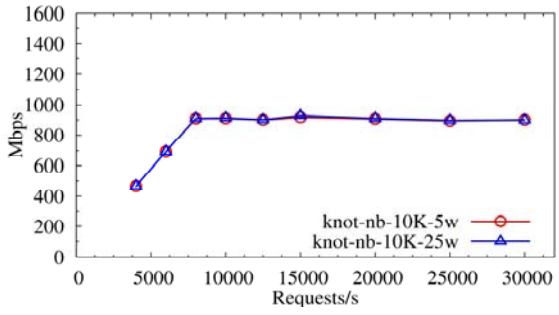

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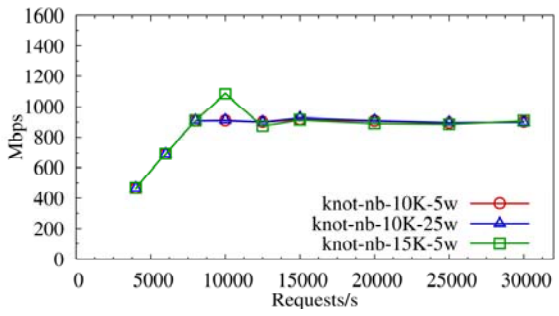

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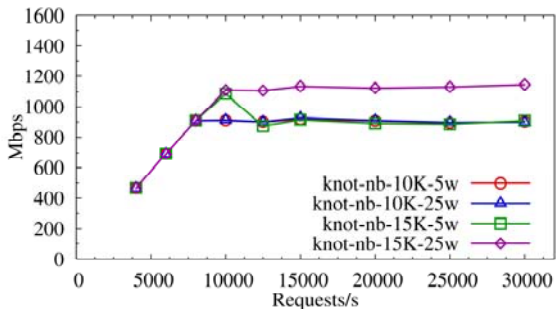

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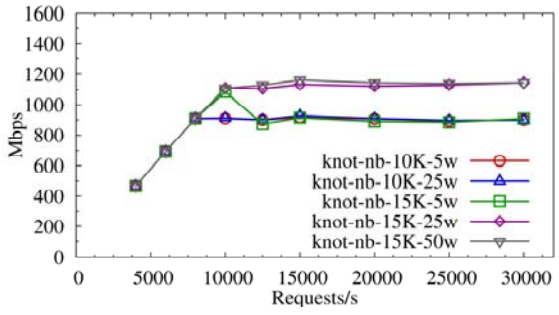
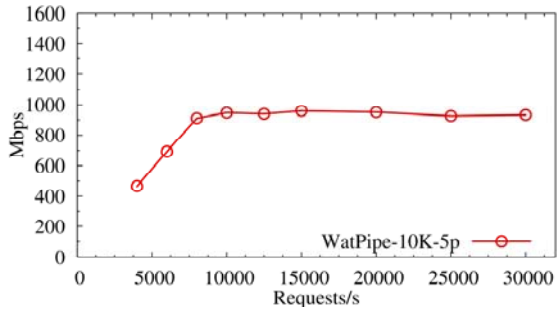


Hybrid / WatPipe



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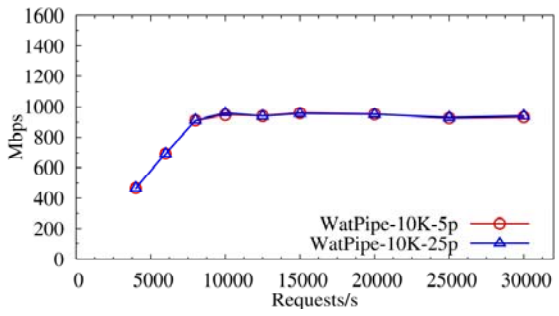

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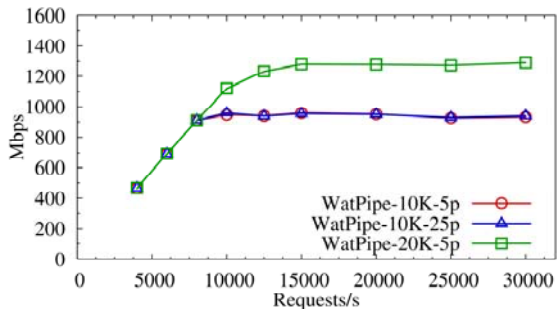

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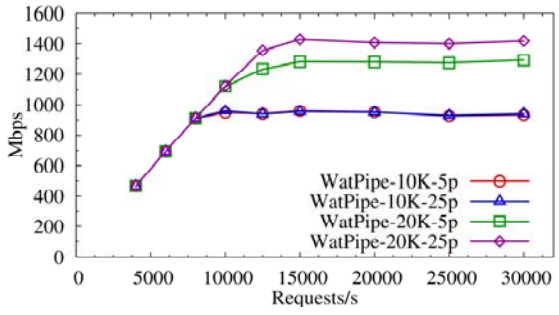

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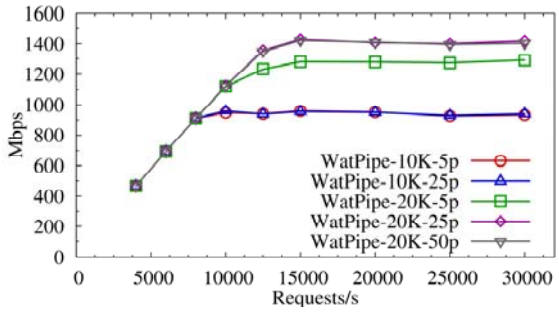
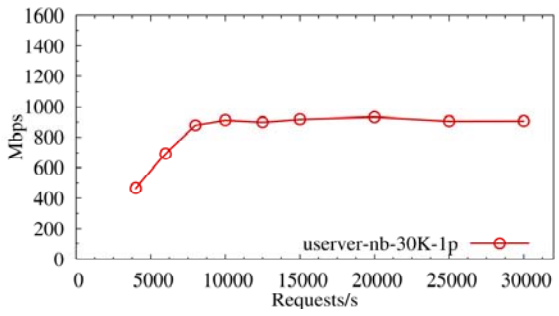


Comparing the Best of Each Server



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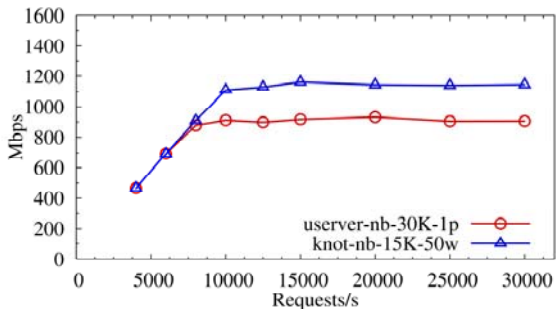

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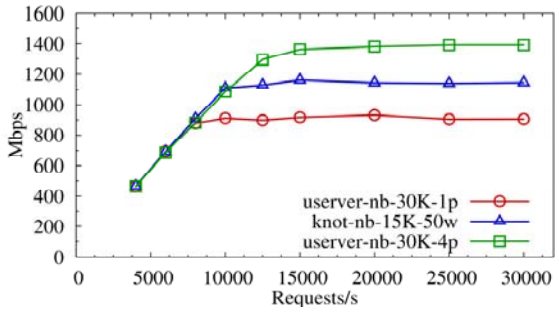

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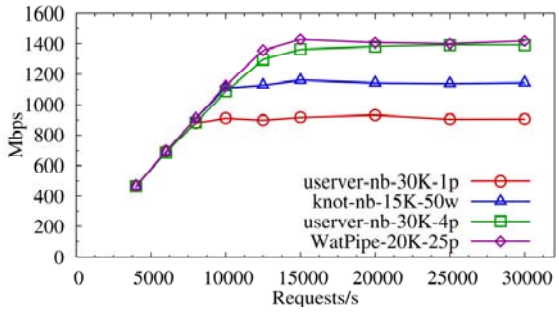
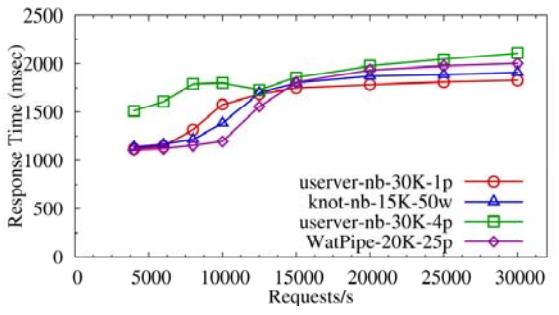


Comparing the Best of Each Server (RT)



SUMMARY

- SYMPED (userver) ~= Pipelined (WatPipe) >
- MT (Knot/Capriccio) >=
- SEDA (Haboob) >
- AMPED (Flash) ~>
- SPED (Flash) >
- MT/MP (Flash) >
- Apache

SUMMARY

- SYMPED (userver) ~= Pipelined (WatPipe) >
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Really? – Under which workloads?
How well were the servers tuned?
What about multiprocessor environments?

Epilogue

- BUT ...
  - Threads Cannot Be Implemented As a Library, Hans Boehm, Proceedings of the ACM SIGPLAN 2005 Conference on Programming Language Design and Implementation (PLDI), June 2005, pp. 261-268.

SO CLEARLY EVENTS ARE BEST ☺

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Some Ongoing and Future Research

- **Problem**: Tuning is a huge pain
- **Research**: Automatic and dynamic tuning
  - Existing servers use static configuration parameters
  - Dynamically adjust parameters (e.g.,):
    - number of connections
    - number of processes/workers/helpers
  - Goal: start a web server, it configures itself
    - Processors, Memory, Disks, Workload
    - Performance sufficiently close to manual tuning
  - Probably requires better understanding & models

Some Ongoing and Future Research

- **Problem**: 80-90% of CPU time is spent in kernel
- **Research**: Improve Application / OS Interaction
  - Improve operating system implementation
  - Change application to better use existing interfaces
  - Add new system calls and modify apps to use them
  - Unable to utilize 10 Gbps Ethernet cards effectively
    - Can utilize 8 x 1 Gbps ethernet cards better than 1 x 10 Gbps
    - 100 Gbps cards have been demonstrated

Some Ongoing and Future Research

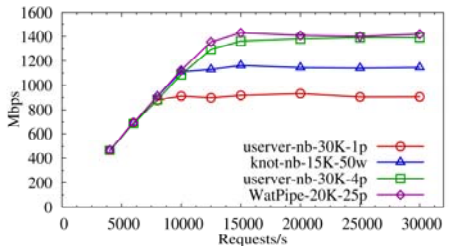
- **Problem**: Most research: Single CPU, static requests
  Most servers: Multi-processor, dynmamic
- **Research a)**: Effective utilization of multi-processors
- **Research b)**: Improving dynamic requests
- **Research c)**: Combining the two
  - improve communication: web & app servers
  - # of app servers, how much cpu power, autotuning

  E.g.: 4 cpus, how many web server processes,
  how many app server processes, does it matter
  where they run?

Some Ongoing and Future Research

- **Problem**: When to stop improving performance?
- **Research :** How fast could a server possibly run?

Best Possible?



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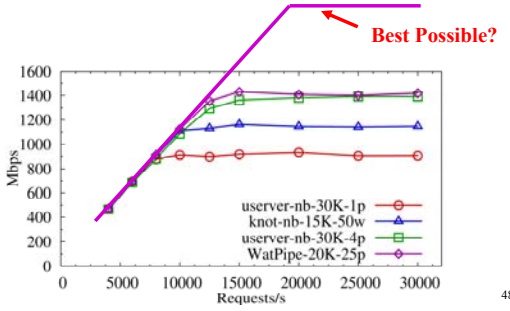

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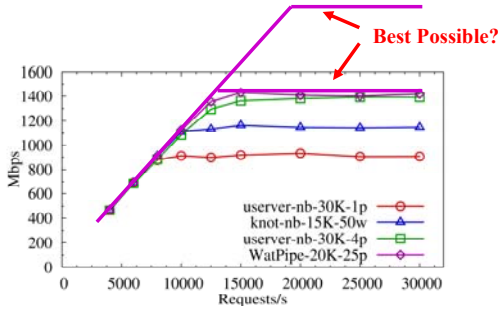

Some Ongoing and Future Research

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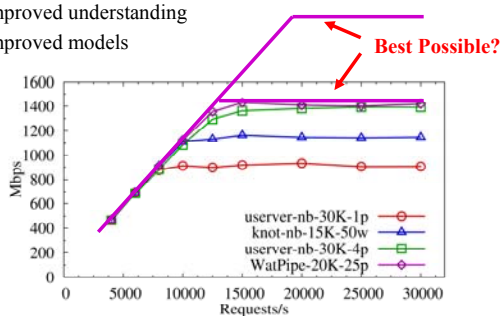
  - improved understanding
  - improved models



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