The M^3 (Measure-Measure-Model) Tool-Chain for Performance Prediction of Multi-tier Applications

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Overview

Application Performance Prediction

Testbed

Target

different workload mix

multi-core

hyper-threaded

different processor architecture

virtualized

power-managed

in a cloud

Production hardware most often *different* from testbed hardware

Problem Statement

Given the results of performance measurement of an application A on a testbed platform X, Predict the resource utilization, response time and throughput of application A on a target platform Y .

Challenges:

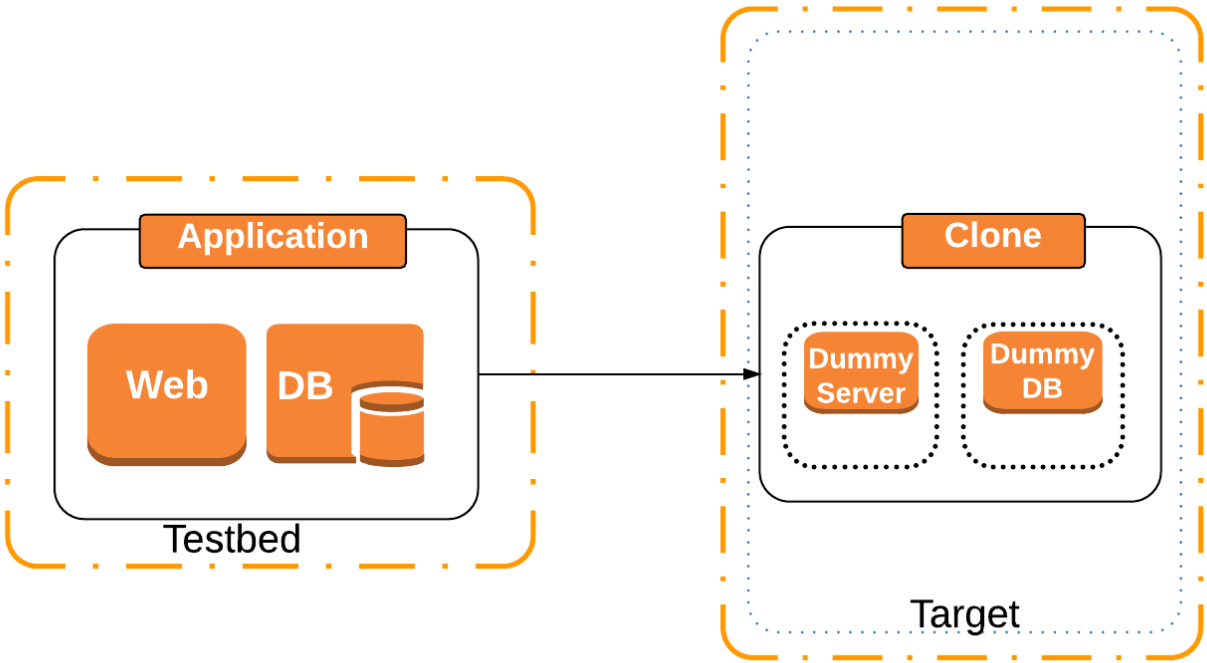
- May be difficult/impossible to deploy entire original application on target and load test it
- Modeling also requires resource service demands of application on *target*

Key idea: Performance "Clone"

- Generate a simple "clone" (A program that mimics the performance of the application on the testbed.)
- Deploy and measure the *clone* (instead of the original application) on the target
- Measure resource demand of clone on the target
- Use this as an estimate of resource demand in a *queueing system model* of the application on the target

In this work focus is on CPU-intensive Web tier

The Clone - Architecture



- Mimics the application, matches CPU service demand
- Works with only a "dummy" back-end tier

The Clone Code

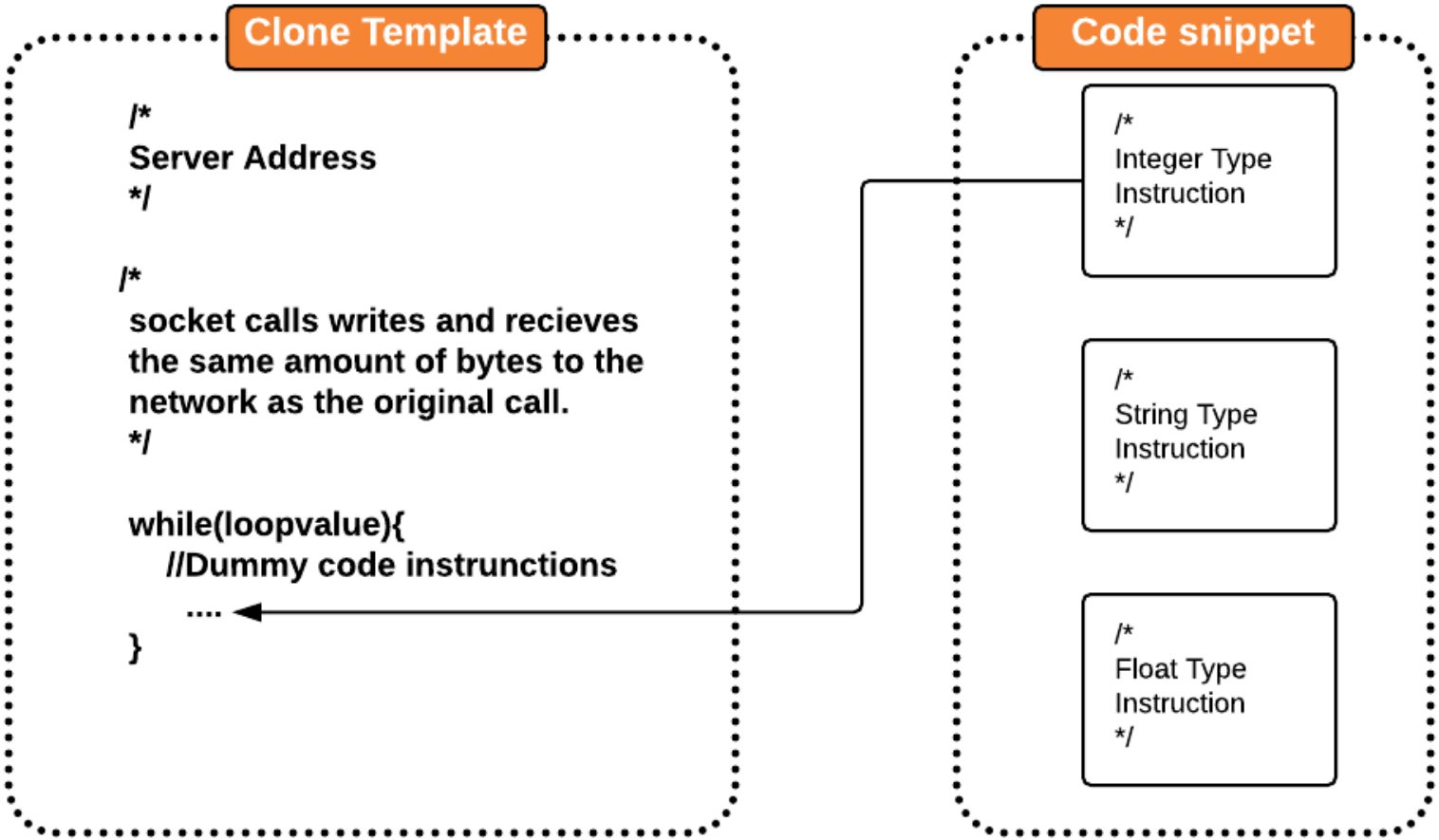


Figure: Clone Template

The M^3 Toolchain

We use a "chain" of *measurement* and *modeling* tools developed in-house to implement the clone-based performance prediction approach.

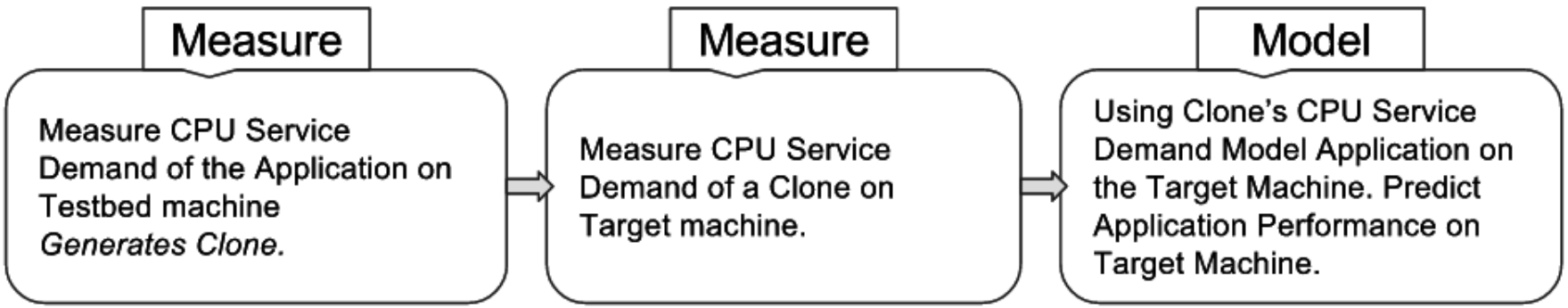


Figure: Three-step hybrid measurement and modeling approach

AutoPerf CloneGen AutoPerf Model

The M^3 Toolchain

Tool pipeline

1. AutoPerf:
   Profile the application performance on the testbed platform.
2. CloneGen:
   Generates clones of the application server-side request codes that are easier to run on the target platform.
3. AutoPerf:
   Measure the clones performance on the target platform.
4. PerfCenter:
   Produce application performance metrics on the target.

Toolchain: Measure Application Service Demand on Target

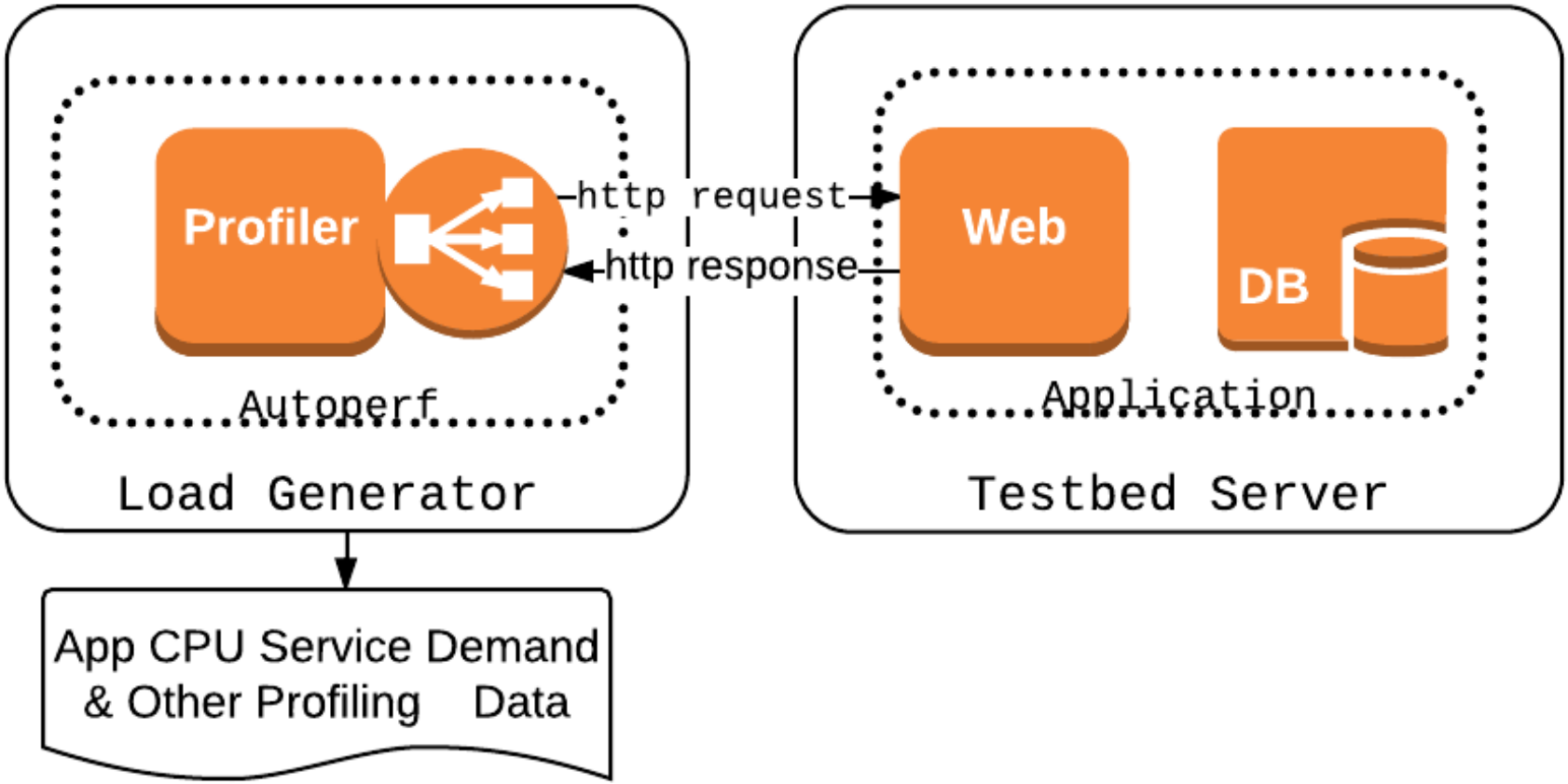


Figure: Profile the application

Generating the Clone

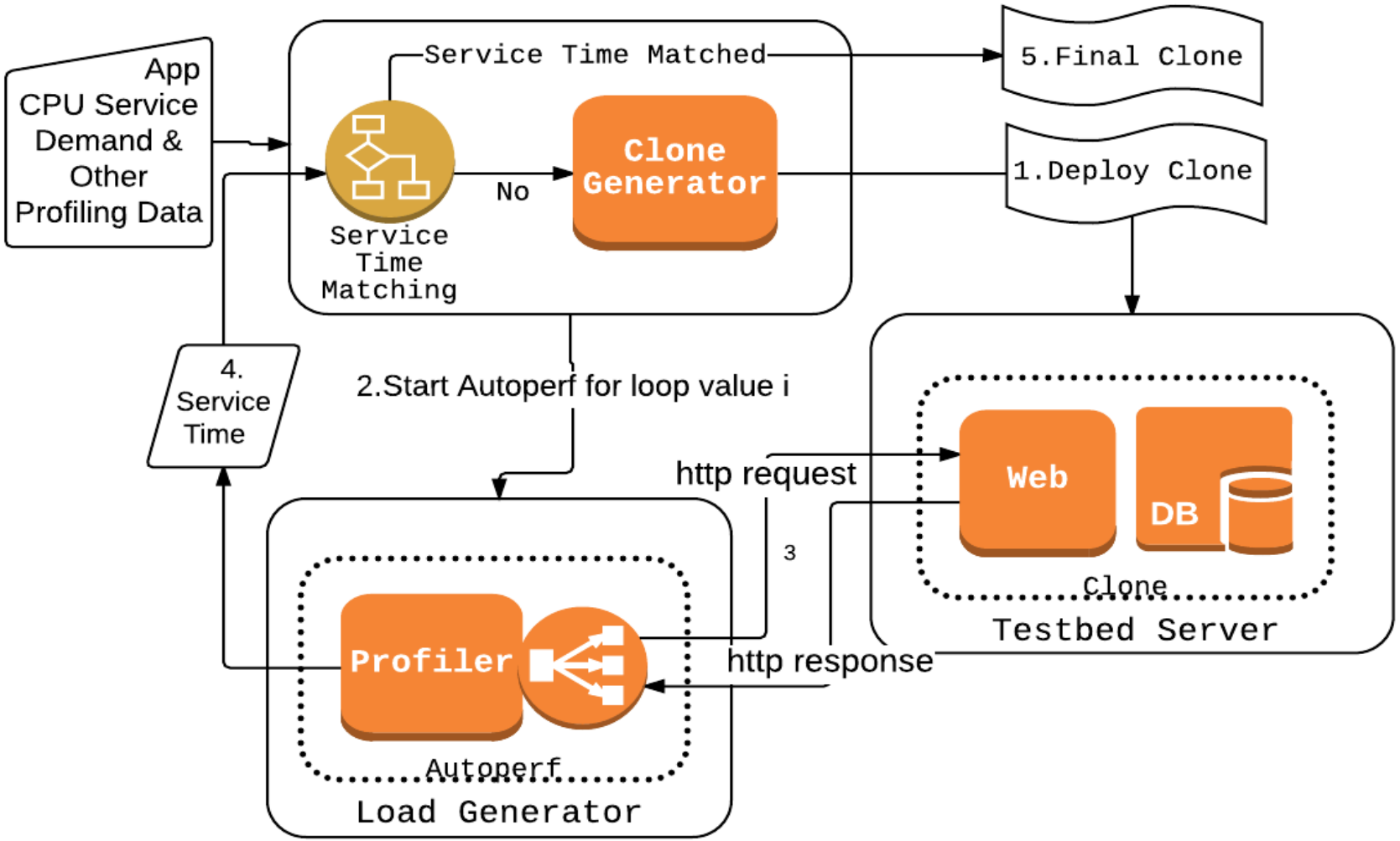


Figure: Desired Service demand achieved by tuning loopvalue

The M^3 Toolchain: CloneGen

Input

1. Number of back end(DB) calls.
2. Sent and received bytes exchanged between web and DB server.
3. Service time of the Application on web and DB server.
4. Type of instructions of code snippet used in the Clone benchmark.

Inputs to the CloneGen

sample input file

number_of_BackEnd_Calls = 4
serviceDemand_of_App_on_Web= 0.0016
serviceDemad_of_App_on_db = 0.0019
bytes_from_web_to_db = 120
bytes_from_db_to_web = 400
bytes_from_web_to_client = 1100
type_of_instructions = string
client_machine_server_address = 10.129.X.X
testbed_machine_server_address = 10.129.X.X
target_machine_server_address = 10.129.X.X

Toolchain: Measuring Clone Service Demand on Target, using it in a model

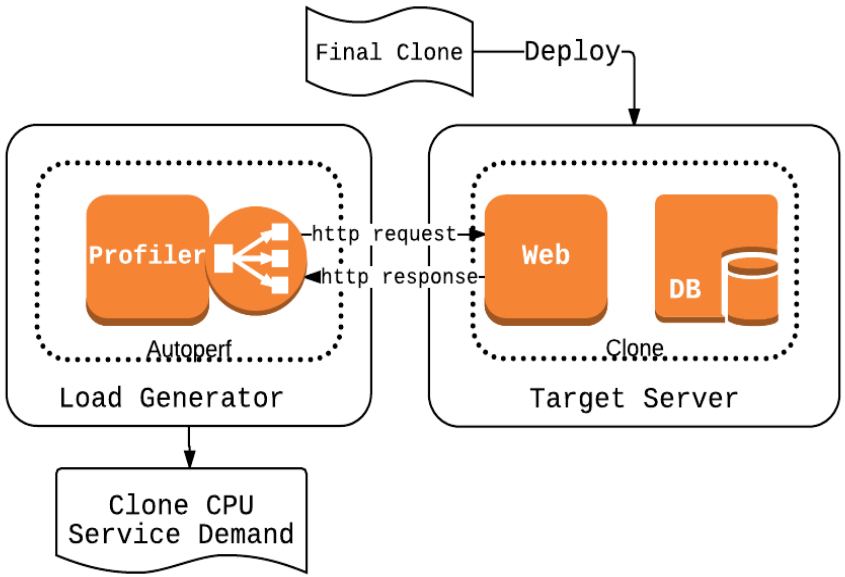


Figure: Measure Clones Service demand on Target

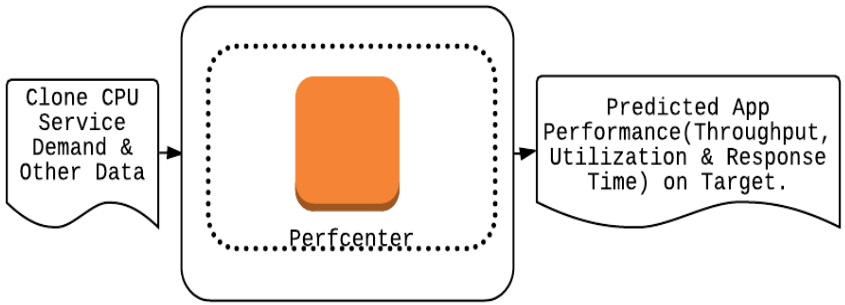


Figure: Predict App Performance

The M^3 Toolchain: PerfCenter: Modeling, Prediction

Input

1. Measured Service demand: **Clone's CPU Service Demand - from Toolchain**
2. Hardware details of Target: **Number of devices, Number of CPU's - manually specified**
3. Message flow details: **bytes exchange between servers - measured separately and specified**

Output

1. Modeled Application Throughput
2. Modeled Utilization of host CPU
3. Modeled Application Response Time

The M^3 Toolchain: PerfCenter: input file

```
variable
    nusr 1
end
device
    markov_cpu
    raid_disk
    disk_array
end
host server_host[2]
    markov_cpu count 4
    markov_cpu buffer 99999
    markov_cpu schedP fcfs
    raid_disk count 16
    raid_disk buffer 99999
    raid_disk schedP fcfs
end
task search_item
    markov_cpu servt 0.00116
end
task view_item
    markov_cpu servt 0.00132
end
task view_userinfo
    markov_cpu servt 0.00105
end
task execute_query
    markov_cpu servt 0.00075
end
task get_response
    markov_cpu servt 0.000001
end
server web
    thread count 2600
    thread buffer 0
    thread schedP fcfs
    task search_item
    task view_item
    task view_userinfo
    task get_response
end
server db
    thread count 2600
    thread buffer 0
    thread schedP fcfs
    task execute_query
end
deploy web server_host[1]
deploy db server_host[2]
lan
    lan1
end
deploy server_host[1] lan1
deploy server_host[2] lan1
scenario SearchItem prob 0.3334
    search_item execute_query 222
SYNC
    execute_query get_response
2550
end
scenario ViewItem prob 0.3333
    view_item execute_query 240
SYNC
    execute_query get_response
836
end
scenario ViewUserInfo prob
0.3333
    view_userinfo execute_query
260 SYNC
    execute_query get_response
700
end
loadparams
    noofusers nusr
    thinktime 0.3
end
modelparams
    method simulation
    type closed
    noofrequests 50000
end
print
" Users,respt,tput,util(server_host[1]:markov_cpu),
util(server_host[2]:markov_cpu)"
for nusr = 100 to 100 incr 100
print
nusr+","+respt()+","+tput()+","+util
(server_host[1]:markov_cpu)+","+util(server_host[2]:markov_cpu)
nusr=nusr+5
end
```

Clone's CPU Service Demand

Host Specification

Server Specification

Message Flow

Validation

- We used two standard Web benchmarks(DellDVD, RUBiS) with various combinations of testbed and target platforms.
- We compared measured vs modeled metrics by using our measure-measure-model approach.

Experiment Combinations

Server Type	Specification
AMD1	16 core Opteron(tm) Processor 6278 @1.4 GHz - 2.4GHz, 16GB RAM
AMD2	16 core Opteron(tm) Processor 6212 @1.4 GHz - 2.6GHz, 16GB RAM
Intel	24 core Xeon(R) CPU E5-26200 @1.2GHz - 2.60GHz, 16 GB RAM

Table : Server specifications

Type	Application	Server (Testbed-Target)	Cores,Frequency (Testbed-Target)
C1	DellDVD	Intel-AMD1	2,2.4 - 2,1.6
C2	DellDVD	Intel-Intel	2,2.4 - 2,1.6
C3	DellDVD	AMD2-AMD1	2,2.4 - 2,2.4
C4	DellDVD	AMD1-Intel	2,1.6 - 2,2.4
C5	RUBiS	Intel-AMD1	2,1.4 - 4,1.6
C6	RUBiS	Intel-AMD1	2,1.4 - 4,2.4

Table : Testbed and Target Combination Specification

Measured vs Modelled: Throughput, Utilization

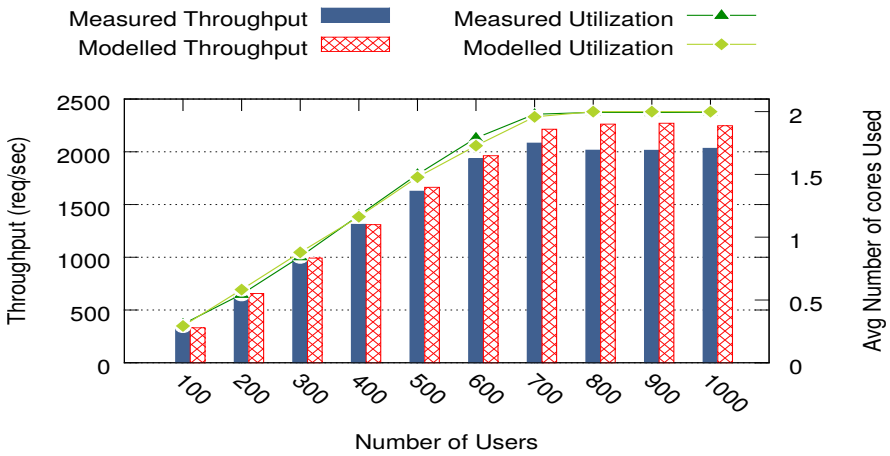


Figure: Combination 1

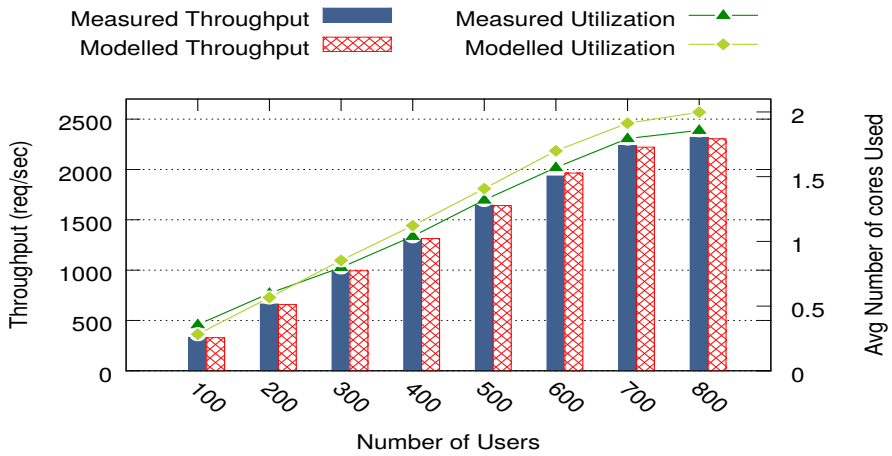


Figure: Combination 2

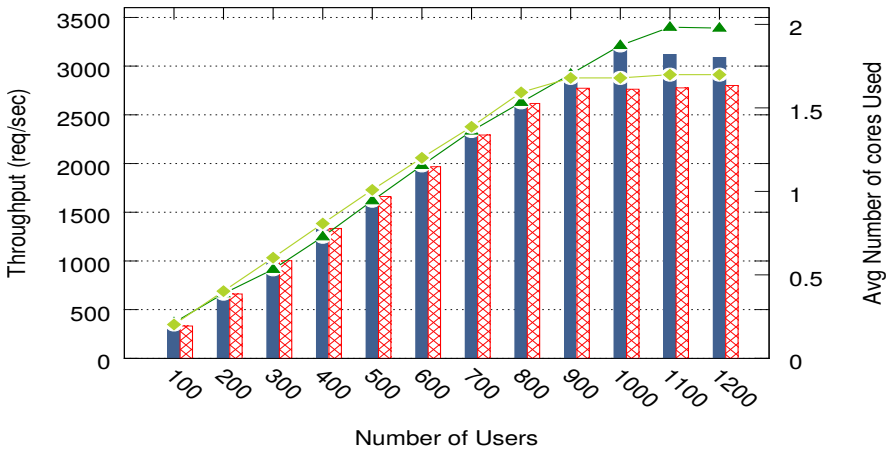


Figure: Combination 3

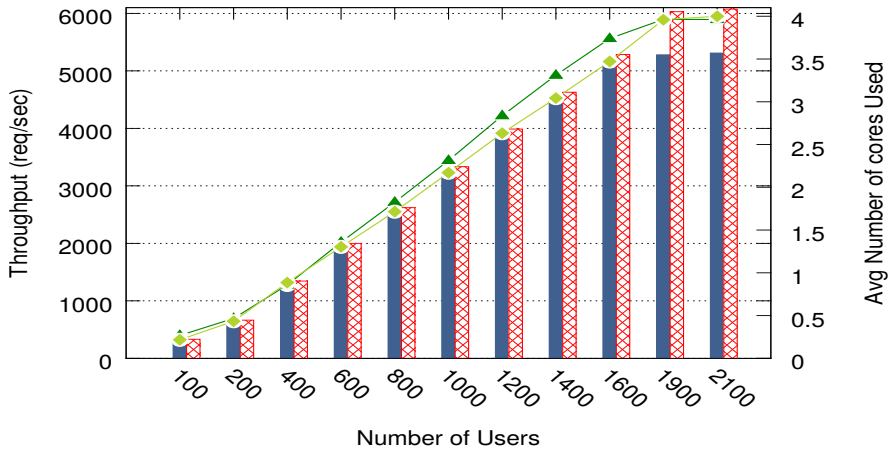


Figure: Combination 4

Measured vs Modelled: Response Time

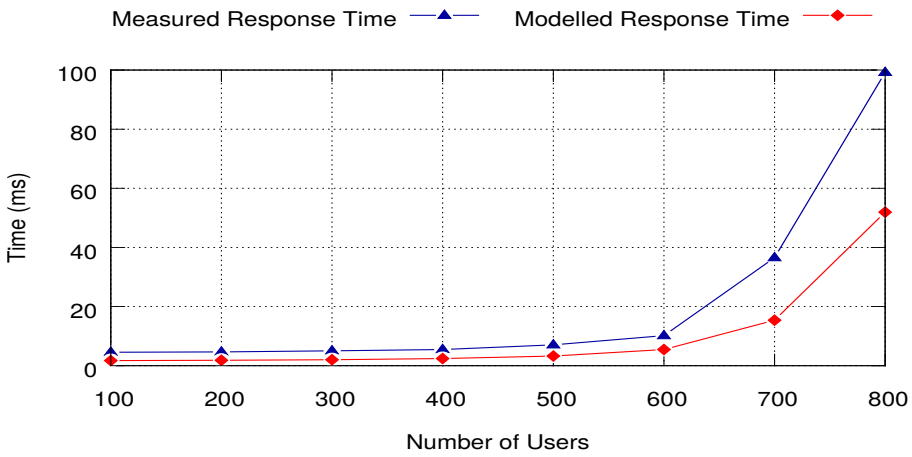


Figure: Combination 1

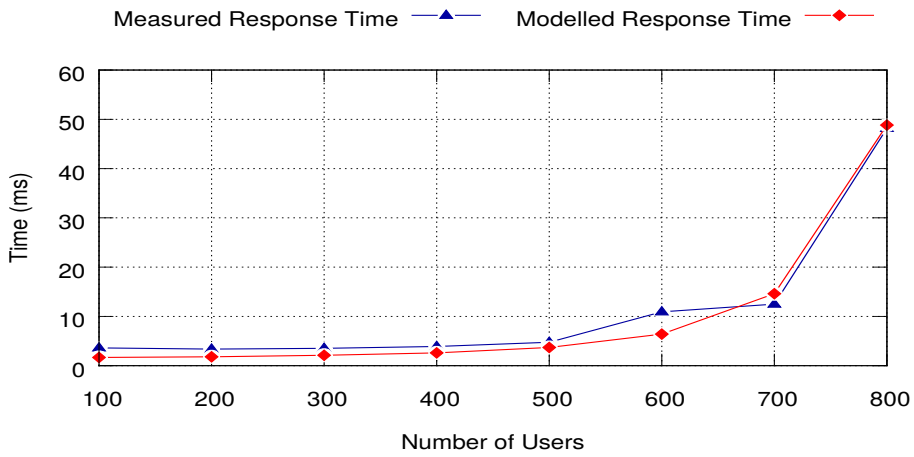


Figure: Combination 2

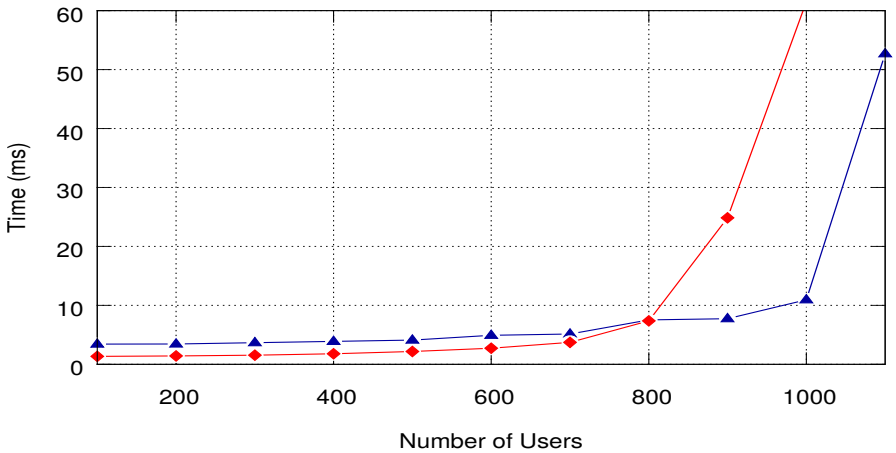


Figure: Combination 3

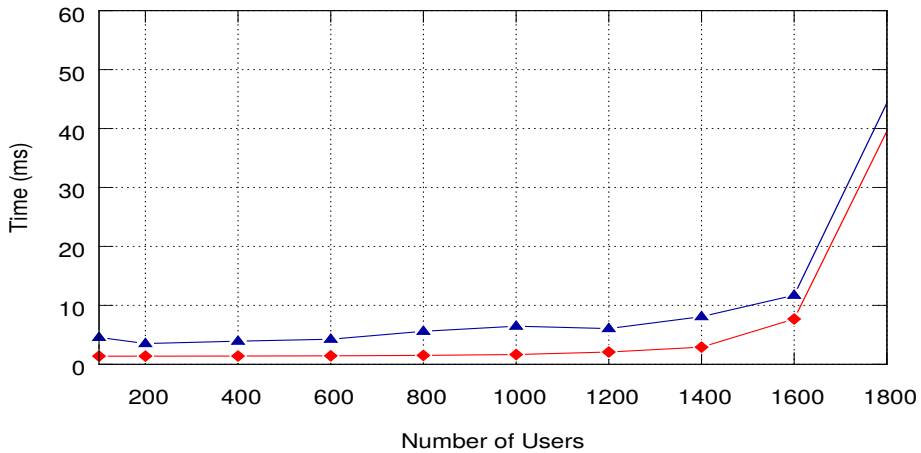


Figure: Combination 4

Measured vs Modeled: Error frequency distribution

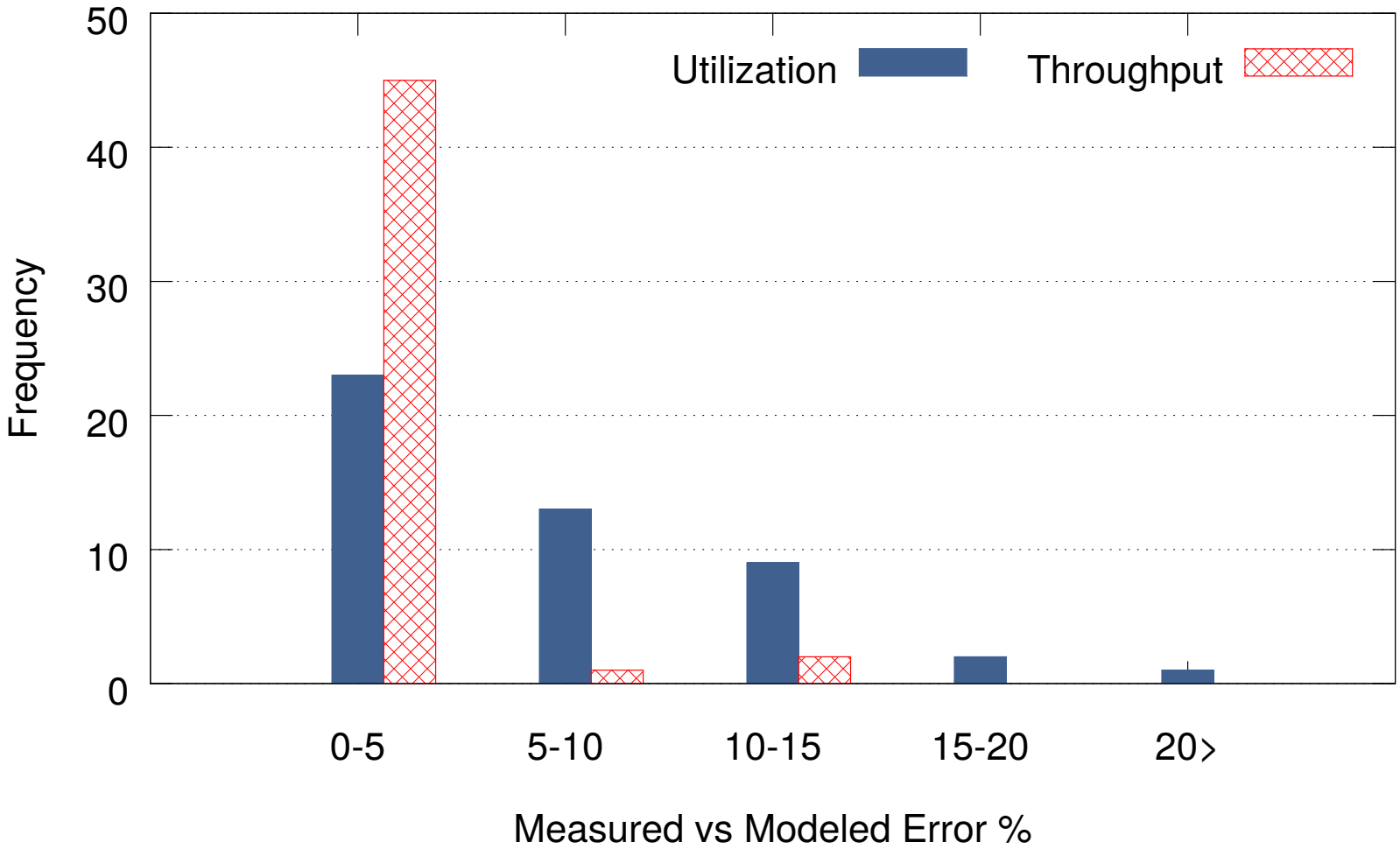


Figure: Histogram of Measured vs Modeled Error %

Conclusion and Future work

Conclusion

- Proposed the Measure-Measure-Model (M^3) methodology for application performance prediction.
- Demonstrated how a tool-chain of measurement, clone generation and modeling tools can be built for the purpose of automating this methodology (partially).
- Validated our approach on two standard Web benchmarks with various combinations of testbed and target platforms.

Future work

- Support a range of resource demands over a certain frequency distribution.
- Validate and if required extend our approach to Web applications written in Java.
- Predict application performance in a virtualized environment.

Thank you.